National Aeronautics and
Space Administration

2012

Reduced Gravity Education Flight Program

Annual Report

Table of Contents

Reduced Gravity Education Flight Program Overview

The Reduced Gravity Education Flight Program provides an unique academic experience for undergraduate students and educators to successfully propose, design, fabricate, fly, and evaluate a reduced gravity experiment of their choice over the course of six months. The overall experience includes scientific research, hands-on experimental design, test operations, and educational/public outreach activities.

Objectives

- To provide students and educators with an outstanding educational opportunity to explore microgravity
- To attract outstanding young scholars to careers in math, science, and engineering in general
- To introduce young scholars to careers with NASA, particularly in the space program
- To provide a platform for students and educators to understand how microgravity affects research and testing of serious science and engineering ideas
- To provide an opportunity for both the general public and school children to discover educational and professional opportunities available at NASA

Significant Outcomes

- To date, student teams from all 50 states have flown. These include 3,539 undergraduate students from 203 universities.
- Over 100 college undergraduates from 20 states (representing 25 different institutions) participated in the undergraduate student program. Eighteen proposals were selected for the 2012 flight year. Nine projects focused on engineering concepts, seven on physical science experiments, and two on life science (including biology) experiments.
- About 65 college undergraduates and faculty in the System Engineering Educational Discovery (SEED) program from eight states (representing 10 different institutions) participated in the 2012 program. The projects in this flight week were all system engineering based.
- Around 46 participants worked with the High Schools United with NASA to Create Hardware (HUNCH) flight teams that flew with the SEED Flight Week.
- Over 30 K-12 educators from 10 states (representing 14 institutions) participated in the NASA's Microgravity eXpereince (Teaching From Space) Flight Week. Twenty-five applications were submitted for the 2012 flight year.
- Over 40 K-12 educators from NASA Explorer Schools (NES) participated in the 2012 program. This is a collaboration between NES and the Reduced Gravity Education Flight Program.
- Each selected flight team will also be required to complete a 3-5 minute video of their Reduced Gravity Education Flight Program experience (including how the experiment was selected, hardware build-up, activities in Houston, and results). Students have posted several of these videos on YouTube and other various video sites.
- Several flight teams have submitted papers to present at various STEM-related conferences during the Fall 2012 semester, including the American Institute of Aeronautics and Astronauts (AIAA) Conference.

Program Overviews

Undergraduate Student Program

The Reduced Gravity Education Flight Program allows teams of undergraduate science and engineering students nationwide to propose, design, and fly a reduced gravity experiment.

The 2012 flights came from all over the United States, with participants from 20 states representing 25 different institutions. Eighteen proposals were selected for the 2012 flight year. Nine projects focused on engineering concepts, seven on physical science experiments, and two on life science (including biology) experiments.

All 18 selected teams were able to complete their projects for flight. This included the first team from Bryn Mawr College (all-female school in PA) and Delaware Technical and Community College, which is the first institution in Delaware to participate. Also, this year we have one team that represents multiple first-time institutions including: Atlantic Cape Community College (Mays Landing, New Jersey), Chapman University (Orange, California), DePaul University (Rolling Meadows, Illinois), Montgomery County Community College (Rockville, Maryland), Northern Illinois University (DeKalb, Illinois), Santa Ana College (Santa Ana, California) and William Raney Harper College (Palatine, Illinois).This year's participants in the NASA Reduced Gravity Education Flight Program Student Program reported to Ellington Field in June and July. The following pages contain abstracts about each project. Full final reports are available upon request.

Systems Engineering Education Discovery (SEED)

The Education Office offered a nationwide solicitation of student applications aimed at addressing systems engineering challenges within a microgravity environment. Unlike the traditional reduced gravity flight program where students propose the research to be carried out, the NASA technical workforce identified ongoing projects that are systems engineering and reduced gravity related. Selected student groups were then paired with NASA research projects under the leadership of a NASA Principal Investigator to carry out scientific research, hands-on investigational design, test operations, and educational/public outreach activities.

In addition to student involvement, one university/college faculty member was invited to fly with each team. This helped to provide faculty members with teaching materials in their classroom and is used as a motivator to increase their students' interest in systems engineering.

The 2012 flights came from all over the United States, with participants from eight states representing 10 different institutions. Twenty-three projects were submitted from NASA Ames Research Center, Glenn Research Center, Jet Propulsion Laboratory, Johnson Space Center, Kennedy Space Center, and Marshall Space Flight Center. Ten proposals were selected for the 2012 flight year. Overall, the nine selected teams were able to complete their projects for flight. This year's participants in the SEED Program reported to Ellington Field in April. The following pages contain abstracts about each project. Full final reports are available upon request.

HUNCH Participants

The High School Students United with NASA to Create Hardware (HUNCH) project provides work experiences to inspire high school career technology and engineering academy students to pursue careers in science and engineering fields. HUNCH is a collaborative effort among NASA Human Exploration and Operations mission directorates and Marshall Space Flight Center's Academic Affairs, Training and Crew Operations, and Ares Project offices. They provide "work-world" experiences for students by engaging them in the design, fabrication, and rapid prototyping of multiple products for use in the ARES I mock-up. High school students will be challenged to meet NASA's work requirements as they coordinate to plan, design, and model hardware for the Ares I upper stage and J-2X engine. Students will use a 3-D plotter for integration of parts and materials.

Eight teams were selected for this opportunity, representing five states from across the United States, reporting to Ellington Field in April. The following pages contain abstracts about each project. Full final reports are available upon request.

Microgravity eXperience (Teaching From Space) Flight Program

Teaching From Space (TFS), located in the Astronaut Office at Johnson Space Center, manages Education Flight Projects, a NASA Office of Education Elementary and Secondary project. TFS activities are national in scope and involve formal and informal education communities and other NASA Education projects.

TFS facilitates education activities that primarily involve K-12 educators and students. These educational opportunities are designed to inspire, engage, and educate educators and students in science, technology, engineering, and mathematics (STEM) disciplines using NASA unique content and resources. TFS provides K-12 educators and students with instructional and learning experiences that utilize NASA missions, content, people, and facilities. These experiences include educator professional development opportunities and hands on student activities that connect them real time to the Agency's mission and future space exploration.

This flight week is being offered through a partnership between Teaching From Space and the Reduced Gravity Education Flight Program. This flight opportunity will allow K-12 teachers and students to propose, design, fabricate, fly, and evaluate an experiment in a reduced gravity environment. Teachers and students will share their experiences and research in an online community.

Seven teams were selected for this opportunity, representing six states from across the United States, reported to report to Ellington Field in February. The following pages contain abstracts about each project. Full final reports are available upon request.

NASA Explorer Schools

NASA Explorer Schools (NES) provides access to high-quality STEM classroom resources and professional development to educators across the country. In the 2010-11 school year, the project reached teachers in more than 1,300 schools. NES recognizes teachers, schools, and students who become highly engaged, demonstrate innovative use of STEM content in the classroom, and use research-based best practice in implementation.

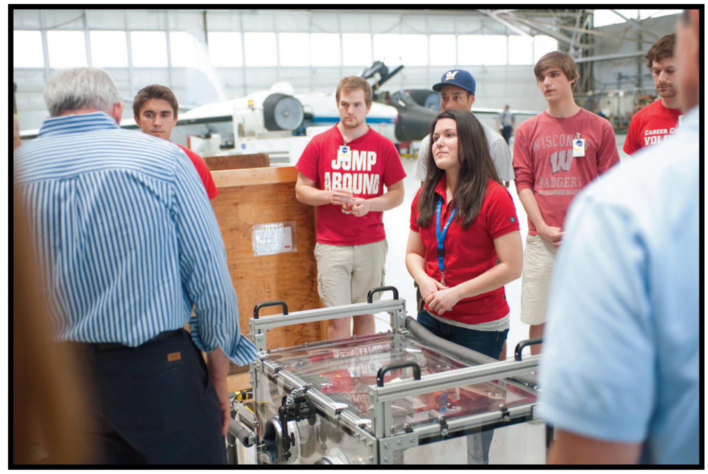
Schools who demonstrate exemplary participation in the project and engage a broad school population can become eligible for school recognition. Schools must have a minimum of three NES teachers at the school, one of whom demonstrates in-depth use of NES classroom resources. Schools then submit an application describing their efforts to engage the school-wide population in NES activities.

In September 2011, 14 schools were recognized by NASA Explorer Schools for broadening the impact of NES beyond one classroom during the 2010-2011 school year. Three teachers from each of these schools had the opportunity to participate in a reduced-gravity flight experience at NASA's Johnson Space Center in Houston, Texas.

The 2012 Reduced Gravity Education Flight Program opportunity provided to the NES teachers was newly created in support of these recognized schools. The schools built and evaluated three experiments that teachers later performed during flight. The sixth month process included live video conference connections with RGEFP staff to discuss experiment production and analyze collected data.

The 2012 flights came from all over the United States, with participants from 10 states representing 14 different institutions. This year's participants in the NES program reported to Ellington Field in February. The following pages contain brief school profiles of each of the recognized schools. Full final reports are available upon request.

Abstracts



Top, left: Educator displays “got gravity” sign for outreach activities.

Middle, left: Educator from Kranz Elementary floats a ball in microgravity.

Bottom, left: Students from University of Florida gathering data from their team’s experiment.

Top, right: Students from University of Wisconsin in Madison explain their hardware to the Test Readiness Review Committee prior to flight.

Middle, right: Students working with NASA HUNCH program monitor their experiment in flight.

Bottom, right: Student from Purdue University floats a sign in microgravity.

Undergraduate Student Program

Participating Universities – By State

**** First Time Participant (institution)***

State	Institution	Page	State	Institution	Page
AZ	Arizona State University	6	MA	Massachusetts Institute of Technology	8
CA	Santa Ana College*	9	MO	Missouri University of Science and Technology	8
CA	University of Southern California	10	PA	Bryn Mawr College*	7
CO	University of Colorado at Boulder	9	TX	Lamar University	7
CT	Yale University	12	TX	University of Texas at El Paso	10
DE	Delaware Technical and Community College*	7	UT	Utah State University	11
FL	University of Florida	9	VA	Virginia Polytechnic Institute and State University	11
ID	Boise State University	6	WA	University of Washington	10
IN	Purdue University	8	WV	West Virginia University	11

Arizona State University: Tempe, Arizona

Dust Coagulation in Microgravity

Proposal ID: 2012-25354

The Arizona State University Dust Devils Microgravity Team proposes to utilize the Reduced Gravity Education Flight Program to observe the coagulation of dust particles in microgravity environments. Specifically, the experiment will focus on determining the mechanisms responsible for triboelectric charging of particles by varying size and composition of the dust particles studied. This test is preformed to constrain existing theories on electrostatic properties of dust coagulation, specifically the research of Desch & Cuzzi (2000) and Kok & Renno (2008). The microgravity environment will enable the observation of these weaker dipole interactions between particles. In addition, this experiment will include a simulation of a protoplanetary disk environment by testing coagulation of meteorite powders. Better understanding of this coagulation mechanism will provide insight into the formation of planets from proto-planetary disks as well as the charging effects of particles on planetary surfaces.

Boise State University: Boise, Idaho

Calcium Flux in Osteocytes and Osteoblasts Due to Gravitational Manipulation

Proposal ID: 2012-25399

Osteocytes are sensory cells that integrate mechanical information into chemical signals relayed to osteoclast and osteoblast effector cell populations, orchestrating bone resorption and formation activities, respectively. While these activities are essential for the maintenance of healthy bone, imbalances in these processes instigated by transition to extreme environments such as microgravity are hypothesized to lead to pathological bone loss such as that observed in astronauts. Changes in free calcium concentration act as intermediates in these signaling processes. Therefore, it is pertinent to determine in a specific, quantitative sense, how environments of continually alternating forces effect calcium concentrations in bone cells. To this end, the proposed experiment will examine how osteocyte and osteoblast mono- and co-cultures respond to the oscillating periods of hyper- and microgravity of parabolic flight. A previous experiment by the 2011 Boise State Microgravity Team demonstrated a strong correlation between changes in the gravitational environment and changes in free cytosolic calcium concentrations in MLO-Y4 osteocyte-like cells. Due to low sample count and the production of quality data on only a single flight, it is necessary to validate the 2011 results. The experiment proposed herein will improve upon the previous experimental system used to fluorescently monitor calcium flux in parabolic flight, introducing greater quantitative power through increased sample number and uniformity. This will be accomplished through replacement of the modular, photo diode-based detection systems with a lens and CCD-based system that monitors the entire sample set simultaneously. Further, the previous cuvette-based sample format will be replaced by an arrayed microtiter plate, rendering the instrument more amenable to standard laboratory preparations and greatly increasing sample number while decreasing the overall amount of biological material required.

Bryn Mawr College: Bryn Mawr, Pennslyvania

Determining the Porosity of Martian Soil Simulant in Microgravity

Proposal ID: 2012-25346

Current models of Martian soil involve a largely imprecise theoretical estimate of soil porosity in the regolith, and the value can vary by up to 30 percent. The aim of this experiment is to obtain a more accurate measure of the porosity of Martian aeolian deposits. Soil from the Mauna Kea volcano in Hawaii, when weathered, has been found to be an acceptable analog for Martian soil, as it has a highly similar spectral signature and chemical composition. An ASD visible-to near-infrared field spectrometer will be used to collect spectral data of this analog soil, JSC Mars-1, in a closed container in a microgravity environment that simulates Mars gravity environment. A curve of spectral data taken over a range of gravitational values will allow us to more accurately estimate porosity of the simulant and provide an improved approximation of Martian soil porosity. A spectral model known as the Hapke model will later be employed to compare theoretical values of spectra at varying porosities to experimental values obtained over the course of the experiment. These results can play an important role in scientific models and studies which seek to more accurately understand the mechanical and compositional properties of Martian soil.

Delaware Technical and Community College: Newark, Delaware

Vertical Projectile Motion with Drag in 1-g and 0-g Environments

Proposal ID: 2012-25371

Our proposed experiment is to demonstrate the effects of gravity and drag on a projectile's vertical motion. Specifically, it compares and contrasts the upward motion of a vertically launched projectile in a drag/1-g environment with that in a drag/0-g environment. On Earth, a vertically launched projectile will be influenced by the forces of gravity and drag. Because of these downward forces, the projectile's vertical speed will quickly approach zero. At that point, it will begin to descend. Under zero gravity, the projectile will only experience drag. Under these conditions, the projectile's speed will slowly decrease, but it won't come to rest or descend. We will launch a projectile under the drag/0-g conditions on board the Reduced Gravity Education Flight Program aircraft. This will be done inside a transparent tube so that the event is contained but still visible, and so that the event can be video recorded. Given the spatial constraints of the tube, the projectile will still have non-zero vertical motion when it reaches the maximum possible distance traveled. At the ceiling of the tube, the projectile will make contact with a switch that will turn on an indicator lamp. In the land-based, drag/1-g environment, the same equipment and techniques will used. Under these conditions, the indicator lamp will remain off for the entire duration of the projectile's vertical motion, since the projectile will never reach the tube's ceiling. The videos of the two events will be a dramatic demonstration of the effects of gravity and drag on a projectile's vertical motion.

Lamar University: Beaumont, Texas

Wave Dispersion on a Torsion Wave Machine in Accelerated Reference Frames

Proposal ID: 2012-25348

Some mechanical systems will behave differently depending on the strength of the gravitational force; in particular systems that exhibit wave phenomena may have dispersion effects that depend on gravity. Our experiment will measure the effect of gravity, specifically at the gravitational accelerations of zero and approximately 1.8-g, on wave dispersion. For the experiment we will use a torsional wave machine, which is a common classroom tool for demonstrating different aspects of waves, but is also useful to measure the exact effects caused by gravity on wave dispersion. This dispersion poses a unique engineering design challenge that must be considered in all systems that oscillate. These challenges might include any fluid pumping systems where cavitation is present. The cavitation in a pump will cause the system and all connected components to vibrate. If the natural frequencies are not taken into account when designing the system, damage could occur. Another example is cylindrical tubing, in particular those used in the space station, which is made primarily of such materials. The tubing in normal gravity would "sag" and have vibrational modes that would be different in zero gravity. Also any type of bridging or connectors could be considered. Changes in the strength of gravity may lead to changes in the natural resonant frequencies of such systems. If changes in the natural frequencies of the system are not taken into account there could be incidents arising from undesirable resonances similar to those of the Tacoma Narrows Bridge or the Millennium Bridge.

Massachusetts Institute of Technology: Cambridge, Massachusetts

Human-Mediated Testing of Guidance, Navigation and Control for Hopping/Landing Vehicles in the Neighborhood of a Near-Earth Object

Proposal ID: 2012-25375

The use of guidance, navigation, and control (GNC) algorithms to direct a space vehicle's movement in the neighborhood of a large object (such as a Near Earth Asteroid, or NEA) in a microgravity environment is currently an area of increasing interest. Our experiment will use a parabolic flight aircraft's interior as the proximate surface of a NEA or other sufficiently large NEO near which an exploration vehicle must maneuver. The vehicle will use GNC software developed jointly by Draper and MIT as part of the Terrestrial Artificial Lunar And Reducedgravlty Simulator (TALARIS) project [1, 2]. Since operating the vehicle's actuators onboard a parabolic flight aircraft would introduce the need to mitigate associated hazards, our GNC will be run without automated actuation. Instead, the flyers of our experiment will respond to commands given by our software through a user interface to "bump" the vehicle in the appropriate manner in order to simulate realistic control events.

We will demonstrate our GNC's ability to function in a microgravity environment by attempting an escalating series of flight operations, including delivering a distance range and extending to commanding a steady hover. Additional flight operations, such as directed motion from one point in space to another, will be attempted if initial results permit.

By running a succession of GNC tests with our vehicle in microgravity, we will both supplement ongoing GNC tests in an Earth-gravity lab and provide some preliminary documentation and testing for GNC development as applied to future scientific and manned missions to NEAs and other bodies of interest that exist in microgravity environments.

Missouri University of Science and Technology: Rolla, Missouri

Microgravity Testing of ACD-CPR Device

Proposal ID: 2012-25353

Students from Missouri University of Science and Technology work with their experiment in parabolic flight.

As technology continues to grow and advance, it will not be long before space travel becomes available to the public. When that day arrives, it will be important to have certain emergency procedures in place. One of the most crucial emergency procedures is cardiopulmonary resuscitation (CPR).

This year, the goal of the Miners in Space is to improve the current CPR procedure through the use of an active compression-decompression (ACD) device. Standard CPR compresses the chest in order to manually pump blood through the body. ACD-CPR uses a device that lifts the chest in addition to compressing it, which improves blood flow. The device has a suction cup on one end and a handle on the other. The suction cup attaches to the chest, and the handle is used to both lift and compress the chest.

In order to test the effectiveness of the device in space, the Miners in Space will first perform ACD-CPR on a test dummy while on the ground. The test will then be performed in a simulated zero-g environment while the test dummy is strapped to the floor. The final test will be to perform ACD-CPR while the test dummy is tethered to the floor, allowing it to move more freely and safely simulating a more immediate response situation compared to the time required to strap the patient to the floor. The Miners in Space will then use the collected data to help create a more effective CPR emergency procedure for microgravity environments.

Purdue University: West Lafayette, Indiana

Exploration of Capillary Fluid Transition in Microgravity

Proposal ID: 2012-25372

Two-phase liquid-gas systems and their associated dynamics are present in a number of spaceflight systems. Therefore, understanding the interim stages and transition time between stable topologies is important to the micro-electrical-mechanical systems (MEMS) field because the breakup of an interface may disrupt device operations. Disruptions in the field can cause many problems and malfunctions, particularly in applications that rely on smooth and steady fluid flows susceptible to air bubbles forming within the system. For example, these air bubbles can inhibit the coolant transportation in a spacesuit or disrupt propellant flows into a rocket engine. The goal of this experiment is to characterize the transition time between several liquid topologies, the results of these experiments which can motivate advances in unique computational fluid methods to further understand fluid dynamics. Transitions will be studied by using the same test liquid in several container geometries and modifying the boundaries of these geometries. The boundary modifications to be performed in this experiment will be the flattening of a circular tube, the planar bending of a circular tube, the raising and lowering of the top surface of a rectangular container, and the raising and lowering of a v-shaped surface in and out of a channel. Lastly, liquid addition to a circular tube will be used to observe a liquid topology transition in a constant container geometry situation. As no dynamic capillary fluid research has been conducted in these geometries (a few RGEFP teams previously studied static stability, not the more complex dynamics the team seeks to study), the objective of this experiment is to explore the time scales of different topology transitions and gain preliminary, yet crucial insight into the problem. This experiment requires microgravity because the necessary scale to attain useful results is impossible in Earth gravity and computational methods are currently very unreliable for capillary-dominated dynamic fluid flow.

Santa Ana College: Santa Ana, California
Nanostructured Metallic Foams Created through Self-Propagating High Temperature Synthesis
Proposal ID: 2012-25401

Individuals on this team represent Atlantic Cape Community College (Mays Landing, New Jersey), Chapman University (Orange, California), DePaul University (Rolling Meadows, Illinois), Montgomery County Community College (Rockville, Maryland), Northern Illinois University (DeKalb, Illinois), Santa Ana College (Santa Ana, California), University of Oklahoma (Norman, Oklahoma) and William Raney Harper College (Palatine, Illinois).

When conducting self-propagating high temperature synthesis (SHS) experiments under the influence of gravity, the process is disrupted. It is theorized that gravity has an adverse effect on each of the four zones (ISMAN). The creation of nanostructured metallic foams through SHS in microgravity conditions has yielded foams far superior than those created from ground based creation. We will be creating foams using aluminum and silver oxide as our reagents. Previous foams made from these reagents have proven to have antimicrobial properties. This is significant because the foams may be used in biomedical implants and could potentially promote re-growth of tissue (Tappan). Through this experiment, we will be comparing many properties of aluminum/silver oxide foam created in microgravity versus ground-based creation, including surface area, density, ignition time, ignition temperature, porosity, permeability, structural elongation, and burn rate. Antimicrobial properties will also be tested by exposing the foams to bacteria and comparing the results.

University of Colorado at Boulder: Boulder, Colorado
Free Convection Correlation in Reduced Gravity
Proposal ID: 2012-25357

Free convective heat transfer, as a function of various surface geometries and different flow conditions, is well characterized with analytical models, which correlate to empirically derived results. However, gravity's impact on these empirically derived models is not established; current correlations characterize free convective heat transfer on Earth in a 1g environment. And ultimately, understanding free convective heat transfer's dependency on gravity will be important to future human exploration. As humans begin to travel beyond the boundaries of Earth, gravity levels will vary with each destination. Therefore, the design of thermal systems for pressurized space habitats would benefit from a thorough understanding of the gravity-dependent correlations that describe free convective heat transfer. Thus, this experiment's goal is to empirically characterize free convection as a function of gravity. It is hypothesized that the Churchill-Chu correlation for free convective heat transfer from a vertical plate is correct and will be experimentally validated. If the results show otherwise, a correction factor shall be defined to account for the deviation.

University of Florida: Gainesville, Florida
Turbulent Liquid Helium Chilldown of a Pipe under Microgravity and Terrestrial Conditions
Proposal ID: 2012-25381

Cryogenic fluids are involved in the propulsion and thermal management of space missions, as well as in medical and industrial applications. Furthermore, the future of space exploration is highly dependent upon the ability to supply cryogenic fluids to spacecraft in a safe and reliable manner to ensure the functionality of propulsion devices, life support equipment and power generation systems. One of the most challenging aspects of working with cryogenics is that transporting such fluids requires the system to be initially chilled down and to maintain the cryogenic in its liquid state. During the transportation process, gravity plays a key role in the flow pattern development as well as the heat transfer mechanism. On Earth, cryogens are forced to contact the bottom wall of the duct due to gravity. However, in a microgravity environment, the cryogens tend to flow through the center of the duct, while vapor contacts the duct's wall forming an inverted annular flow. This results in an increased chill down time due to the vapor film between the liquid and the duct that decreases the heat transfer rate. The objective for this experiment is to expand upon last year's research by studying liquid helium, rather than liquid nitrogen. This cryogen was chosen because its properties closely resemble those of liquid hydrogen, which is commonly used as a rocket propellant. Additionally, this research is relevant to superconducting magnets, MRIs and other research applications where liquid helium is utilized. A more complete characterization than the one performed during last year's study is expected by recording the flow visually from multiple angles, and by studying the effects of complex pipe geometries that are commonly used in industry on chilldown rate and flow patterns.

University of Southern California: Los Angeles, California

The Effect of the Radiative Properties of Gases on Combustion Behavior in a Microgravity Environment

Proposal ID: 2012-25407

This experiment aims to develop an understanding of the relationship between radiative heat transport and combustion behavior in a microgravity environment, where buoyancy-driven convective heat transfer does not interfere with the reaction. A better understanding of the radiative properties of gases on the burn rate of combustion reactions has the potential to influence related fields such as fire safety in space as well as diesel engines and similar internal combustion mechanisms. For this experiment, wax balls are ignited in three different gaseous environments while under microgravity conditions to highlight the effects of radiative heat transport by showing that higher reabsorption rates cause faster burn rates. For this experiment to be effective, it must be conducted in a microgravity environment so that the buoyancy-induced convective heat transfer can be negated, showing only the effects of radiative heat transport on the burn rate.

University of Texas at El Paso: El Paso, Texas

Combustion Mechanisms of Lunar Regolith/Magnesium Mixtures

Proposal ID: 2012-25361

The utilization of lunar/planetary resources (in-situ resource utilization – ISRU) is a technology that is critically needed for the advancement of future missions to the Moon, Mars, and beyond. Regolith could be used for production of construction materials that are needed to build landing/launching pads, radiation shielding, and other structures on the lunar/planetary surface. Specifically, mixing regolith with metals such as magnesium and aluminum creates thermite-type mixtures that, upon ignition, exhibit self-sustained combustion leading to the formation of ceramic composites. This process may be affected by gravity due to the presence of liquid materials in the combustion front and natural convection in gas phase around the sample. The project investigates the effect of gravity on the combustion wave propagation and the product microstructure for the mixtures of JSC-1A lunar regolith simulant with magnesium. The proposed experiment is a follow-up to the reduced-gravity tests conducted in June 2011. The experimental setup will be modified to include thermocouple measurements of the sample temperature during combustion. Also, the gravity effect on the spin combustion regime, recently discovered in these mixtures, will be investigated. The enhanced experiments will generate results that allow for better understanding of the combustion mechanisms in regolith/magnesium mixtures.

University of Washington: Seattle, Washington

Centrifugal Method for Particle Size Segregation

Proposal ID: 2012-25350

Students from University of Washington work with their experiment in flight.

Extraterrestrial regolith can be utilized for a number of purposes in long-term missions to many celestial destinations. In order for the regolith to be useful, it must be sorted by size determined by the proposed use of the regolith. Current sifting methods require the use of terrestrial gravity to successfully sort the sample. However, terrestrial gravity is not available anywhere but Earth, and a sifting method that works in variable or minimal gravity is vital to successful, long-term, manned and unmanned missions.

The experimental design consists of a rotating shaft with an attached sifting container. The container has a series of two sequential screens that segregate particles by size. When the container is spun, the regolith particles are pushed radially outward toward the screens where the sifting occurs. The particles that are trapped between the two screens are the target size. When the test is completed, gates next to each screen are engaged to keep the regolith sorted, maintaining the data for analysis post flight.

The experiment is designed to test the viability of the sifting mechanism to operate effectively in microgravity, as well as in terrestrial gravity, in order to demonstrate that the sifting mechanism operates independent of the gravitational field to which it is subject to. Additionally, the experiment will test parameters such as sample size, duration of sorting, and rate of rotation to determine the most efficient use of power as well as the accuracy of the sorting mechanism.

Utah State University: Logan, Utah

MACS & FUNBOE: Microheater Array Cooling System and Follow-up Nucleate Boiling On-Flight Experiment

Proposal ID: 2012-25377

Because of its high heat transfer rates, nucleate boiling is an efficient method of moving a large amount of heat from a small area. This property makes nucleate boiling a desirable method of controlled heat transfer. However, the absence of buoyancy and the complex behavior of the boiling phenomena in microgravity require further research before optimal heat management systems can be used effectively in space. Microheater Array Cooling System and Follow-Up Nucleate Boiling On-flight Experiment (MACS & FUNBOE) is a continuation of the study on nucleate boiling on twisted wire geometries tested by the previous FUNBOE projects and includes the analysis of unique microheater arrays as a potential cooling system for microelectronics systems on satellites and spacecraft. MACS & FUNBOE will build upon the results of the previous experiments and further the understanding of established nucleate boiling systems by: completing the boiling data from nucleate wire boiling systems used in previous FUNBOE experiments through measuring the critical heat flux of triple and quadruple twists of thin wires, investigating the boiling behavior of microheaters as an application of the knowledge gained in studying wires, observing the forces that act upon microheaters and arrays of microheaters during nucleate boiling in microgravity, and exploring the use of microheater arrays to reduce the minimum heat flux required to begin boiling. This approach will provide insight into boiling behavior and potential heat transfer enhancements.

Virginia Polytechnic Institute and State University: Blacksburg, Virginia

Internal Linear Actuator Satellite Attitude Control

Proposal ID: 2012-25356

A novel, linear, internal moving mass actuator system is being developed for consideration as the primary attitude actuation system of a Virginia Tech 3U CubeSat mission set to launch within the next two years. The system will use two masses moving linearly along orthogonal axes. Numerical simulations of the dynamics for a 3 unit (3U) CubeSat of dimensions 11.81” x 3.937” x 3.937” (30 cm x 10 cm x 10 cm) and a total mass of about 6.6-8.8 pounds (3kg - 4kg) have demonstrated smooth rolling and pitching maneuvers of up to 30 degrees using single .5 pounds (0.25 kg) masses, displaced by 1.969” (5 cm) as properties of the internal moving masses. Additional numerical simulations have demonstrated that coupled motion profiles of the mass actuators (sweeping through the actuator space) can produce net roll, pitch, and yaw maneuvers even with the masses retracted to the equilibrium positions. This dynamic effect, known as holonomy, produced with low actuator rate and moving mass weights, suggests the viability and efficacy of an internal mass actuator based satellite attitude control system. In addition, the ability to discretize when and how maneuvers are performed can extend actuator lifetime, reduce susceptibility to mechanical wear, and reduce power requirements compared to traditional attitude control systems such as thrusters and momentum exchange devices.

West Virginia University: Morgantown, West Virginia

Electrostatically Enhanced Fluidized Bed in Microgravity

Proposal ID: 2012-25394

The purpose of this experiment is to explore a proposed means for allowing fluidized beds to be used in microgravity conditions. For a fluidized bed to function properly on Earth, it has been determined that the gravitational force is necessary. Because of the absence of significant gravitational forces while in microgravity environments, another body force is required. The proposed experiment will test the effects of electrostatic forces on fluidized beds and determine whether an electric force will be able to substitute for the gravitational force. To test this hypothesis, an electric field will be created using two charged parallel plates located above and below of a cylindrical bed. The particles within the bed will be charged and placed in this electric field to produce a net Coulomb force on the particles. Inter-particle forces will also be considered due to previous research which has shown that these forces may have an effect on the fluidization of the bed. The magnitude of the electric force must be strong enough to prevent the particles from accumulating at the top of the bed, but not so strong that the particles become packed at the bottom of the bed. The appropriate magnitude of an electric force will effectively simulate Earth’s gravitational force, resulting in a properly fluidized bed in microgravity. A high-speed camera and digital data acquisition system will be used to evaluate the fluidization conditions within the bed.

Yale University: New Haven, Connecticut

On the Behavior of Two-Dimensional Rayleigh-Taylor Instability in Various Gravities

Proposal ID: 2012-25395

The Rayleigh-Taylor instability is a gravity-driven fluid instability that transpires in a wide range of natural and industrial settings. It occurs in any situation in which a dense layer of fluid rests atop a less dense layer, causing a regular pattern to form in the interface between the two fluids as gravity pulls the denser fluid downwards. Given that this phenomena has rarely been studied in gravities other than 1 g, we propose an experiment which aims to observe the instability under both 1.8 g and microgravity, by means of flight on NASA's "Weightless Wonder" zero-gravity research aircraft. We intend to explore the instability in a simple two-dimensional setting - we place a thin layer of a viscous fluid inside a trough, allow it to spread out uniformly, and flip the trough so that it faces downward. On earth, is has been observed that the interplay of the Rayleigh-Taylor instability causes the fluid in the trough to converge into a regularly spaced line of droplets. The time scale regarding the convergence, the distance between each droplet, and the sizes of the droplets have all been shown to depend upon the force of gravity. In the higher gravity case, we expect to observe a much shorter time and length scale for droplet formation; more interesting will be how the system behaves in microgravity, as the predicted length and time scales approach infinity as gravity approaches zero. In the absence of gravity, the outcome we expect to observe is the reversion of the droplets back to the uniform fluid layer.

Students from across the country pose for a picture after successfully completing a microgravity flight.

Systems Engineering Education Discovery (SEED) Students

Participating Universities – By State
** First Time Participant (institution)*

State	Institution	Page	State	Institution	Page
ID	Northwest Nazarene University	13	NE	University of Nebraska at Lincoln	15
IL	University of Illinois at Urbana/Champaign	14	TX	University of Houston at Clear Lake and San Jacinto College	14
GA	Georgia Institute of Technology	13	WI	Carthage College	13
MO	Washington University in St. Louis	15	WI	University of Wisconsin at Madison	15
OK	Oklahoma State University	14			

Carthage College: Kenosha, Wisconsin

Fluid Vessel Quantity Using Non-Invasive PZT Technology Phase 2

This project is phase 2 of the 2010 project which was very successful, demonstrating the use of non invasive PZT technology to measure water mass under microgravity. This follow-up project will demonstrate microgravity Fluid Vessel Quantity measurement using non-invasive PZT sensors and actuators. In a microgravity environment the project is to measure PZT responses to establish quantities of fluid using 1-2 small tanks containing know volumes of water. A reliable method to change levels/then measure the levels will be required which improves on ease of use under plane flight zero g conditions. The PZT based system has been developed by NASA KSC on similar composite tanks and will be a basis for the refined experiment by the SEED team. The flat flexible PZT actuators and sensors are attached to the walls of the water fluid tanks. The system has produced accurate results on four fluid levels from two flights last year. The phase two will require near real-time and post flight frequency based analysis based on NASA PI developed software algorithms. The students will be developing the mechanical and electrical setup and collecting the data using a laptop. The goal of phase two is to provide more fluid level data points, demonstrating the accuracy and repeatability of the PZT Technology.

Principal Investigator: Rudolph Werlink (Kennedy Space Center)

Georgia Institute of Technology: Atlanta, Georgia

Suitport Alignment in Microgravity

Through various trade studies conducted from 2008 to present, NASA has identified the suitport technology as optimal for future exploration missions. From the astronaut perspective, the suitport will decrease the amount of time required for pre-breathe and suit donning/doffing between EVAs and allow them to spend their working hours more efficiently. In order to dock with the suitport, the astronaut must align the suitport interface plate (mounted around the rear hatch opening of the space suit) to the suitport mounted on the vehicle bulkhead and then activate controls to lock the suitport interface plate into position and create a pressure sealing barrier between the vehicle and space. The primary objective of this project is to design and evaluate at least two different methods for suit port alignment and docking in microgravity, with a focus on assessing ingress/egress aids required. The student team will be responsible for the design and fabrication of plane rated vehicle bulkhead mock-up with suitport, human-worn suitport interface plate mock-up, and ingress/egress/alignment systems.

Principal Investigator: Kathryn Mitchell (Johnson Space Center)

Northwest Nazarene University: Nampa, Idaho

Novel Phase Separation Methods in Microgravity using Hydrophobic and Hydrophilic Surfaces

As future human space exploration ventures farther from earth it will become necessary that life support systems become less dependent on the resupply of critical mission resources such as water from earth. Recovery of water from waste items such as leftover food, wet wipes, hygiene wastewater brines, and a variety of other water rich waste items will enable future human space exploration missions to achieve the level of independence required for the long term presence of humans in space but novel approaches to the separation of liquid water from water vapor and air in micro-gravity must be investigated to make such missions feasible. This experiment will explore the use of specially designed hydrophobic and hydrophilic surfaces to achieve phase separation as a lightweight alternative to systems such as centrifuges that contain moving parts that are prone to mechanical failure and are also sensitive to the accumulation of solids that typically precipitate out of waste water during the water removal process.

Principal Investigator: Gregory Pace (Ames Research Center)

Oklahoma State University: Stillwater, Oklahoma
Techniques for Motion Analysis in Reduced Gravity

Students from Oklahoma State University monitor experiment in flight.

The objective of this project is to evaluate various motion capture systems (e.g. Vicon MX, Dartfish, APAS, photogrammetry, etc.) and methodologies identify the optimal combination of methodology and data collection and analysis techniques to capture the full joint ranges of motion required to quantify isolated joint mobility and functional joint mobility as test subjects perform representative EVA tasks. Factors to be considered when selecting the optimal combination include system accuracy, reliability, repeatability, ease of use in aircraft environment, post-processing time required, and extensibility of system and method to other reduced gravity simulators (e.g. Neutral Buoyancy Lab or ARGOS). The key aspects of the experiment design will be defining the motions and tasks to be performed that will indicate extreme limits to motion; defining relations between body segments that will define the joint angles; and creating and locating stable mounting platforms for data recording devices of choice inside the aircraft.

Principal Investigator: Lindsay Aitchison (Johnson Space Center)

University of Houston-Clear Lake and San Jacinto College: Houston, Texas
Robotic Control using Gesture and Voice

Robotic designers are striving to find new and innovative ways of controlling robot systems that increase efficiency, situation awareness and the user's sense of presence. In addition, operating NASA's newest robotic systems will require us to move beyond traditional desktop systems and hand controllers. Voice control and gesture control have not yet been widely integrated into operational robotic interfaces as we have much to learn about the most effective ways to utilize these input modalities. This project will seek to learn about the utility and limitations of controlling a robotic system with voice and gesture commands for two scenarios that are part of NASA's planned future exploration missions. First, is microgravity control of robotic assets external to a spacecraft, such as for asteroid capture and sample manipulation, or for control of ground based robots from orbit. Second is the control of a free-flyer robot, such as a camera system or personal propulsive device. Students will take advantage of graphical simulations of robots and environments to test the various control paradigms. NASA researchers are currently experimenting with the Kinect Motion tracking system and simulations of Robonaut 2 but have yet to implement voice control and define a set of gestures for robotic operations tasks. This will be a unique and timely opportunity for students to help advance our fundamental knowledge in the area of human-robotic interaction.

Principal Investigator: Dr. Jennifer Zumbado (Johnson Space Center)

University of Illinois at Urbana/Champaign: Champaign, Illonois
Human-Systems Integration of Tablet Computing in Microgravity

Tools developed for life on Earth have the potential to improve life on-orbit for astronauts as well, but there are additional challenges associated with microgravity use that must be considered in order to determine whether the use of these tools does add value in spaceflight. An example of such technology is the iPad and other tablet computers that now pervade daily life. Potential use for these tools on-orbit include displaying electronic procedures and timelines, communicating with ground personnel via email or video conference, performing tasks associated with science experiments, and taking advantage of integrated technology for purposes such as recording video and photographs. However, there may be challenges associated with use in microgravity including hardware and software limitations of the tools themselves, integration of the tools into pre-existing communications and data systems, and human interfaces. For this project, we would like a team of students to perform a usability evaluation of a tablet computer in a microgravity environment. Problems that must be considered include optimal mounting of hardware during use, personnel restraints or assistive devices, processes or procedures for hardware use, and strategies for integration of the tool into existing communications and data systems. Expected findings include recommendations based on human factors and systems engineering concerns. A complete assessment will include ground-based pilot tests in addition to a well-designed flight experiment to examine specific tasks and configurations.

Principal Investigator: Sherry Thaxton (Johnson Space Center)

University of Nebraska-Lincoln: Lincoln, Nebraska
Flame Behavior of a MEMS-GC Detector

Students from University of Nebraska at Lincoln explain their hardware to the Test Readiness Review Committee.

As humans travel beyond Earth's orbit, there will be a need for very light, compact and robust instruments for monitoring the crew cabin environment. For the past decade, our group at JPL has been producing miniature gas- and liquid-based sensors for environmental monitoring for including a volatile organic compound (VOC) monitor for the International Space Station. Our partner, Cbana Labs, has developed a series of VOC detectors based on micro-electro-mechanical systems (MEMS) technology. With Cbana, we have been awarded NASA funds to work on sensors for both robotic (PIDD program) and human (Advanced Environmental Sensors) exploration applications. One of Cbana's sensors is a MEMS-based gas chromatograph that uses a micro flame ionization detector (FID) that generates and uses hydrogen via electrolysis. From decades of work on both the Space Shuttle and the International Space Station, it is known that flames, even micro-flames, behave quite differently in microgravity. Therefore, we would like to test the performance of one of the Cbana FID devices in microgravity and compare it to its performance in the lab. The will give us valuable insight into whether or not the current design would still be applicable to spaceflight or if a subtle redesign is needed.

Principal Investigator: Richard Kidd (Jet Propulsion Laboratory)

University of Wisconsin at Madison: Madison, Wisconsin
Space Suit Dust Removal Techniques in Reduced Gravity

One of the proposed future missions for NASA is a visit to an asteroid. Geologists hypostasize that the asteroid's surface may release dust particles when contacted by a space suited astronaut while collecting samples of the asteroid. The space suit will become contaminated with dust during the microgravity EVA. NASA has experience with dust contamination and removal in lunar gravity of dust, but not in microgravity as would be found on an asteroid. The objectives of this flight experiment would be to expose a test article composed of space suit materials (ortho fabric, polycarbonate, RTV) in microgravity, document dust adhesion, and demonstrate dust removal and cleaning techniques. Space suit sample materials would be mounted inside the glove box. A very limited amount of JSC-1 dust stimulant would be in a fixed container inside the glove box. The container is opened during the zero gravity phases. Close-up photos/video of dust adhesion would be taken. A portable "shop vacuum" would be mounted inside the glove box. The team will remove as much of the dust from the space suit materials as possible, and demonstrate other creative dust removal techniques (such as electrostatic wipes) that maybe identified by student team.

Principal Investigator: Robert Trevino (Johnson Space Center)

Washington University in St. Louis: St. Louis, Missouri
Feed Water Supply Assembly (FSA) Proximity Sensor Low Water Level Alert

The Space Suit Portable Life Support System (PLSS) team is pursing the development of an in-suit feed water supply assemble or FSA to serve as an accumulator for the next generation PLSS design. The preliminary design concept is to place a translucent water bladder in the pressurized volume of the space suit. This bladder will provide feed water to the PLSS cooling water loop via the compression of the flexible bladder material by the pressure of the suit. One requirement on this design is the capability to indicate via electric signal when the FSA has reached a low water level. The signaling mechanism must work in various gravity fields including micro-G to be effective. The PLSS team is currently investigating the use of proximity sensor to provide the low water signal. Preliminary 1-G demonstrations have show proximity sensor to be a viable option. A micro-G test of a prototype proximity sensor low-level alert system for the FSA is needed to further the development of this concept. Starting with the work done on the 1-G demonstrator the project team will need design and build prototype proximity FSA low-level alert system. Additionally the team will need to design a test that would verify that the prototype operates in both 1-G and micro-G, build a test fixture, conduct the test and produce a report of their findings.

Principal Investigator: Ian Anchondo (Johnson Space Center)

High Schools United with NASA to Create Hardware (HUNCH) Teams

Participating Schools – By State

*** First Time Participant (institution)***

State	Institution	Page	State	Institution	Page
CO	Warren Tech Career Center	17	NC	North Carolina School of Science and Mathematics	17
CO	Warren Tech Central Campus	17	TX	Clear Springs High School	16
CO	Lakewood High School	16	WY	East High School	16
CO	Overland High School*	17			

Clear Springs High School: League City, Texas
Food Growth Chamber

Clear Springs High School is developing a food growth chamber that can function in a microgravity environment. The chamber will be Nanorack size and will incorporate a nutrient system to provide seedlings an opportunity for growth once activated onboard the International Space Station. Additionally, we will be measuring the CO2, temperature, and humidity of the food growth chamber. The knowledge used from this experiment will be applied to the final development of a food growth chamber that is proposed to supply the ISS crew with fresh food. The experiment is contained inside a box constructed from Lexan, which will be placed inside a NASA glove box to provide double containment of the water that is required. The experiment relies on a COTS submersible water pump, fan, PVC piping, micro-spray nozzles, micronic mesh, high intensity LED lighting, and various sensors. The plants will be of the legume family. We will collect and record data from the readings received from the sensors. During microgravity conditions, data will also be collected by student observations and will be recorded on a digital recorder and camera.

East High School: Cheyenne, Wyoming
The Dispersion of Scents in Microgravity

We are developing a systematic procedure to release organic compounds under microgravity conditions. By the use of specialized sensors for volatile organic compounds, we will measure sensor readings for specified areas of dispersion of such compounds. The knowledge used from this experiment will be applied to an experiment, proposed to improve the scents onboard the ISS for astronauts. Our experiment will consist of a cube lab made of Lexan material approximately 15cm x 10cm x 10cm in dimension. Sensors will be placed in a way that provides 3-dimensional coverage for the dispersion of the organic compound. We will collect and record data from the readings received from the sensors to a Lab Quest. We will also be improving the venting system and release system of the organic compound to provide for a more automatic means of collecting the data we need.

Lakewood High School: Lakewood, Colorado
Hydrofuge Plant Growth Chamber for ISS

We designed and built a Personal Plant Chamber (PPC) meant to grow small plants on the International Space Station (ISS). Our experiment was based off of our previous design which misted the plant and then used a centrifuge system to remove the water from the plants roots to prevent root rot. This year we have experimented with two different designs to find the best system. One of our designs involved an ebb and flow system to water the plant and the other was a system that percolates water through a soil substrate. We are also designed a user friendly control cube for easy use by the astronauts. The control cube will be used to adjust watering levels, the light source, and other important elements for the plants growth. The experiment will be able to fit into one or two Nanolabs (4in x 4in x 4in). If our experiment succeeds on the zero-gravity flight we hope to send it up to the ISS. If our experiment does well on the ISS we designed it in a way so that there can be multiple PPC's connected to grow a variety of plants on the ISS.

North Carolina School of Science and Mathematics: Durham, North Carolina
Spinal Compression Model

Due to reduced gravity, the spinal column elongates in space, creating more space between each vertebrae. As we learned through interviewing former astronauts, this stretches nerves and causes back pain during missions. We plan to investigate solutions for this problem by constructing a scaled-down spinal model and testing spinal tension with proposed treatments. We hypothesize that increased thoracic curvature created by holding one's knees to one's chest changes force distribution and ameliorates pain. Force distribution will be measured along natural and bent spine configurations in microgravity. We are currently examining practical methods to mitigate the effects of spinal expansion.

Overland High School: Aurora, Colorado
Microgravity Water Purification System

Water is one of the most vital factors necessary for support of life and research in an extraterrestrial environment. However, traditional water purification and filtration systems used in a 1G environment are often difficult or impossible to use in a microgravity environment. The current environmental control and life support system (ECLSS) used on board the international space station (ISS) relies on the generation of artificial gravity by spinning the vacuum distillation assembly. Though current techniques are effective at producing high quality water, the reliance on spinning the distillation assembly makes this system vulnerable to mechanical failure. The objective of our project is to develop an alternative method to effectively purify water in a microgravity environment without the reliance on generating artificial gravity. In our system, the dirty feed water is contained behind a vapor permeable membrane. A vacuum pump is used to reduce the pressure in the chamber, causing the water to boil, and move through the membrane as a vapor leaving the contaminants behind. The use of a vapor permeable membrane eliminates the need to control the position of the water by generating artificial gravity. This reduces the number of mechanical components, potentially increasing the reliability of the system. Removing the need to spin the assembly also reduces the power consumption of the ECLSS, which allows the ISS to utilize that energy elsewhere. Alternately, our system may be able to be integrated into the current ECLSS to serve as a contingency plan in the event that the spinning mechanism becomes disabled.

Warren Tech Central Campus: Lakewood, Colorado
Aquaponics System on the ISS

Our team at Warren Tech has come up with an idea to grow plants in a Personal Plant Chamber (PPC) that would potentially go up on the International Space Station (ISS). Taking the main idea from our previous experiment to test water flow through small holes drilled into hoses that water our plants, we have now added a new twist into the layout. We have replaced our regular water basin with a water bladder that will contain shrimp within it. We are going to be using the shrimp as a nutrient supplement for the plants. We will then continue to pump the water from the bladder into the small plant containers to water the plants. With the water bladder, and the plant growth chamber being the size of a Nanolab, this will help to reduce the amount of space used and further get our experiment ready for the International Space Station (ISS).

Student from Warren Tech explains hardware to the Test Readiness Review Committee.

Warren Tech Career Center: Lakewood, Colorado
Frying an Egg in Space

Our design is made to improve astronauts cooking abilities in space. We know how important a homemade meal is to people. Our experiment is based off of our teacher's previous experiment which involved cracking eggs in reduced gravity to observe how the egg would react. We have come up with multiple designs to create our final project which is a combination of aspects from all designs. The idea is to crack the egg and control its whereabouts so that we can fit it into a cylinder that would be heated to fry the egg. There will be a pan spinning for when the egg is cracked so that the centrifugal force will pull the egg to the surface of the pan so it will cook. The experiment will be able to fit into one or two Nanolabs (4in x 4in x 4in). If our experiment succeeds on the zero-gravity flight we hope to send it up to the ISS.

Microgravity eXperience (Teaching From Space) Flight Program – By State

** First Time Participant (institution)*

State	Institution	Page	State	Institution	Page
MI	Warren Consolidated Schools*	20	PA	Council Rock High School South*	18
MT	Target Range and Anna Jeffries School*	20	TN	Lebanon Special School District*	19
MT	Glacier High School*	19	VA	Einstein Fellows	19
OH	Eastern Elementary School*	18			

Council Rock High School South: Holland, Pennsylvania
Remotely Operated 0G Vehicle

As the National Aeronautics and Space Administration (NASA) explores beyond Low Earth Orbit (LEO), crew members might face increased hazards during spacewalks. To decrease the risks associated with spacewalks and protect the crew, NASA will need more robots to execute tasks previously performed by humans. This will include investigating both the internal and external areas of future spacecraft and potentially developing the ability to repair the spacecraft autonomously.

In order to assess potential applications for robotic agents working with astronauts, the students at the Council Rock High School South collaborated with staff members during multiple after-school planning sessions. Students submitted questions about microgravity and how things would respond to that environment. Discussions led to answering the question “what could we develop that would have real- life implications for our space program?” Students discussed how robotics has been instrumental in the inspection and diagnosis of any external surface problems of vehicles while in space. Following the Columbia accident, there was much focus on external inspections of space vehicles. The students looked at improvements to the robotic arm of the Space Shuttle and new inspection procedures established by NASA to diagnose any potential damage to space craft. As their inquiry proceeded, they realized the value of remotely operated vehicles in the inspection and repair process. The team began investigating remotely operated vehicles and a demonstration using an AR Drone was presented to the team. The students came up with the idea of constructing a remotely operated vehicle that could carry out specific tasks in a microgravity environment. To have real life implications, the vehicle would not only have to be able to work in a microgravity environment, but also operate in the vacuum of space. They questioned things such a propulsion and stabilization and decided that the vehicle would need to use compressed air to maneuver and gyros to stabilize. The idea was to create something that could safely and thoroughly inspect a space vehicle with no additional risks to astronauts.

Our experiment will test the effects of microgravity on the control and practical use of a remotely operated vehicle. The vehicle that we design and build will be powered by compressed air so that the technology could be applied to an external space environment. The question we are trying to answer is “Can we get a remotely operated vehicle to stabilize in a microgravity environment, and then perform simple commands (forward/backward, left/right, up/down)?”

The hypothesis that will be tested states that the ROV will operate within a 10 percent deviation from the ground-test results in reaching the designated target. The independent variable that is being tested is the effect of microgravity and the dependent variable that we will measure is the percentage that the rover deviates from our ground-test data. Factors such as the movement of the reference points (the aircraft) and operator error in a microgravity environment could account for this deviation.

Eastern Elementary School: Lexington, Ohio
Electron Flow in Zero Gravity

The Eastern Eagles Team was selected by the Teaching in Space Program to perform an in flight experiment investigating electron flow in zero and hyper gravity. Through this investigation the team will be able to answer the following questions: “Do electrons flow differently in altered gravitational states than they do in 1g?” and “Is the magnetic pull of a horseshoe magnet affected by altered states of gravity?.

Educators from Eastern Elementary take a team photo while floating in microgravity with NASA mentor, Jeremy Hart.

After viewing the NASA videos “What is Electricity” and “Experimenting with Electromagnets” the team began the investigative process with fifth grade students. Constructing a simple electromagnetic circuit using a spinning horseshoe magnet, an iron nail, coiled copper wire, and a 7V hand drill, our students were able to light an LED bulb. Seeing what it took to have the magnet “pull” electrons through the wire, the students were curious to see what would happen if there was more gravitational pull and reduced gravitational pull on the generator. Using a multi-meter the students saw that for 30 seconds they were able to generate 4.28 V of electricity.

Seeing what was possible with 1g, the students hypothesized that with less gravity the voltage would increase and with more gravity the voltage would decrease. Their reasoning was that more gravity would “weigh” the electrons down causing a slower movement and less gravity would allow the electrons to flow more freely producing more voltage. Testing the students’ hypothesis is what the team plans to do in Houston by operating the experiment during both reduced gravity and hyper-gravity portions of the flight.

Einstein Fellows: Arlington, Virginia
Diffusion in Microgravity

Individuals on this team represent The Jewish Community High School of the Bay (San Francisco, California), Kuna High School (Kuna, Idaho), Miami Christian School (Fountainebleau, Florida) and St. Marks School (Southborough, Massachusetts).

If teachers search for experiments to demonstrate diffusion, they will get several experiments as the top hits. One has a teacher put a bit of perfume in the corner of the room (Emerson, 2011). Another has the teacher put a bit of ink in water. A third has a teacher put ammonia at the bottom of a test tube with a piece of litmus paper at the top. The results of these experiments – the smell of perfume throughout the room, the swirling of the ink, and the change of the color of the litmus paper – purport to show diffusion, but in fact show air or water currents that are mostly convection cells. (Davis, 1996)

With that said, convection is a solid experimental design that we would like to test the impacts of gravity on from the initial diffusion based model. Our experiment is going to concentrate on how convection occurs in a sealed liquid model. Since the ground-based experiments utilize the force of gravity to pull the concentrated dye downward, we are expecting a different direction of convection to occur in the microgravity experience.

Further this investigation will allow us to show that a common experiment done in chemistry actually shows something different than is usually argued.

We hypothesize that in free fall the convection will occur so slowly without gravity driving the movement that the dye will not move through the water. We believe that in free fall, the dye will not travel through the water or will travel slower than the models in 1g.

Glacier High School: Kalispell, Montana
Oxygen Generation at Zero G

Electrolysis, the method of using an electrical current to drive a chemical reaction and separate chemical elements, in the classroom works by density difference. The gas that is produced at the electrode bubbles to the top while the electrolytic solution remains at the bottom around the electrode keeping current flow. When at zero g, we predict with the same apparatus that a bubble would form around the electrode until no fluid is touching the electrode which would then stop the reaction and no more oxygen would be produced. With no oxygen being supplied there would be no breathable oxygen at micro-g or in space by this process. The oxygen generation system on the ISS is producing oxygen for the astronauts to breath by the process of electrolysis. The exploration that we are using as a base for our experiment is a NASA lab activity called “A Breath of Fresh Air.” We plan to answer the question will a bubble form around the electrode and then stop the electrolysis. In addition we want to discover whether when the apparatus is spinning can we simulate gravity and keep the electrolysis process from stopping by driving the fluid out to the electrodes.

The team members in this group started with Todd Morstein an Advanced Placement Program (AP) chemistry teacher who wrote and piloted “A Breath of Fresh Air.” He worked with Tonya York to pilot the activity with her AP chemistry students at Manvel High School. The next step was not only to look at the production of oxygen for the astronauts but to look at it from the zero-g or outer space environment. We decided to submit a proposal to begin working on the idea and we began to bring in the other members of the team. Todd Robins is Glacier High School’s AP Physic teacher and worked with the idea of spinning the electrolysis device and how fast it needed to spin. David Hembroff, a Glacier High School Astronomy, Chemistry and Physic teacher, has a passion for space. Brad Holloway, Glacier High Schools AP Statistics teacher, who is helping us with experimental design and data analysis and comparison. We also have groups of students doing the ground work. A group of AP chemistry students are exploring the chemical reactions, and amperage needed for the experiment. AP physics students are exploring the concept of reproducing gravity through centripetal force. AP statistics is looking at different testing and comparison methods for data.

Lebanon Special School District: Lebanon, Tennessee
Sutures in Space

NASA currently uses sutures for wound closure; however, NASA is currently exploring other methods to find a more effective way of closing wounds and reducing infection rate (Arndt, Byerly, Sognier, Ngo, Phan, & Dusl, 2011). Methods under exploration address the area of emergency closure of traumatic wounds incurred while living and working in space, on the Moon, and on Mars. This is a joint effort between the Electromagnetic Systems Branch in the Engineering Directorate and the Biomedical Research and Countermeasures Projects Branch in the

Space Life Sciences Directorate. This research advances the goals of the Human Research Program by developing technologies and tools to enable safe, reliable, and productive human space exploration. (Arndt, Byerly, Sognier, Ngo, Phan, & Dusl, 2011)

Given the interest that NASA has in finding more effective ways to close wounds in low-gravity environments, several ideas for experiments were discussed among teachers, students, and mentors. Since the 8th-grade science standards in Tennessee focus on life science, we decided to focus on an experiment that would not only fit into the curriculum but also allow students to brainstorm ideas that would be useful in the microgravity of space. During our discussions, the following question arose, "How would you close a wound if an astronaut were injured in space?"

There are currently six cosmonauts and astronauts living and working on the International Space Station. In addition, the eventual deployment of a mission to go beyond low earth orbit is in the planning stages. Not only will a mission, such as going to Mars, continue to sustain a permanent presence of humans in space, but will also increase the risk of serious medical events. Astronauts may have to conduct surgical procedures in microgravity.

During our initial research, we found that as a method for closing cuts or wounds, the technique of suturing is thousands of years old. Although suture materials and aspects of the technique have changed, the goals remain the same: closing dead space, supporting and strengthening wounds until healing increases their tensile strength, approximating skin edges for an aesthetically pleasing and functional result, and minimizing the risks of bleeding and infection. But traditional methods, such as needle and thread closures, may not be appropriate for space. We want to investigate types of wound-closing methods and determine which would be the most effective for use in microgravity.

Previous investigations have shown the possible difficulties of performing surgery in microgravity (Brown University, 1999). Additional research is needed before astronauts can confidently carry out even minor surgical procedures in space. New methods that have been developed on Earth for closing wounds, as well as conventional suturing of open surface wounds, may not be appropriate in microgravity. We would like to test three methods for wound closure including stitching, stapling and liquid adhesive.

According to Dr. Duvall, staples compete against traditional suturing methods for closing deep wounds and have been proven to be an effective method for closing wounds for certain surgical procedures. In certain cases, the use of staples can reduce operating time by as much as 60 percent (Duvall, 2011). In addition to stapling as an alternative wound-closing method, liquid adhesives provide results that are comparable with traditional suturing of surface, linear and low-tension lacerations (Duvall, 2011).

Target Range and Anna Jeffries School: Missoula and Cut Bank, Montana
Liquid Layers in Microgravity

This team is comprised of teachers from two school districts and two communities. The Target Range Community and Cut Bank Community are both rural and have a high percentage of Native American students. The Cut Bank community is close to 50 percent Native American population. Although the Target Range community has a slightly lower Native American population, both schools are leaders in promoting Indian Education for All. The reason we chose density as our topic is because we are always looking for innovative ways to add a cultural component to science, math, technology and social studies. Our team took a look at our current science curriculum. We looked for a science, math, social studies and language arts lesson that also had a cultural component. We all agreed that a density lesson would work best inside a glovebox. It also meets all of our state standards. Next we discussed how density relates to the Native American culture because of the conical shape of the tepee and how is helps to circulate air using a convection current idea. Students will also be exposed to NASA's BEST, Mass vs. Weight, NASA Kids Club, and Microgravity activities pre and post flight.

Warren Consolidated Schools: Warren, Michigan
Convection Current Formation in a Micro-G Environment

This experiment will be flown during the Teaching from Space Micro GX eXperience in order to study convection currents. This will provide an exceptional platform to enhance the STEM-based curriculum at a half-day magnet math, science, and technology center that services 11 different high schools in nine different school districts. The experiment will answer the question: will convection currents form in zero gravity and 2g environments?

Educators from Warren Consolidated Schools in Michigan take a team photo prior to flight.

Mark Supal, a Macomb Mathematics Science Technology Center (MMSTC) staff member current serving as an Einstein Fellow at the National Science Foundation in Washington, D.C., learned of the MicroGX opportunity early in September and communicated with the current staff and students at MMSTC. As a research focused high school center, students participate in a comprehensive research project each year, cumulating in a semester long project as seniors. The MMSTC program shows students connections between their research and similar processes that take place in the scientific community. Staff and students were very excited to brainstorm potential topics and experiments to take place in a microgravity environment and with Mark Supal's guidance, decided on the topic above.

NASA Explorer Schools Program – By State

** First Time Participant (institution)*

State	Institution	Page	State	Institution	Page
CA	Charles T. Kranz Intermediate School	21	PA	Jamestown High School	23
CA	Lakewood High School*	24	SC	Forest Lake Elementary Technology Magnet School	23
CA	Ellen Ochoa Learning Center	22	TX	Johnston Middle School*	23
CA	Woodrow Wilson Middle School*	25	TX	Pre-service Teacher Institute	25
CN	East Hartford-Glastonbury Magnet School	22	VA	Mack Benn Jr. Elementary School*	24
IA	Amos Hiatt Middle School*	21	WA	Key Peninsula Middle School	24
ID	Franke Park Elementary	23	WI	St. Mary's Visitation School*	25
NC	Ferndale Middle School	22			

The Experience

The Reduced Gravity Education Flight Program has teamed with the NASA Explorer School Program (NES) to provide a one of a kind flight experience. The flight opportunity is a unique academic experience for teachers to successfully fly and evaluate three reduced gravity investigations. Teams of three educators, from 14 different NES schools, will conduct these STEM investigations in their classrooms and repeat them in the reduced gravity environment.

Descriptions of the STEM investigations are:

Experiment One: Mass vs. Weight

Students and educators will build an inertial balance to determine the mass vs. weight of unknown objects. Students will compare the data from their 1g experiments to the flight experiments and determine what the unknown masses weigh.

Experiment Two: Projectile Design Challenge

Students and educators will build a projectile launcher and data table to analyze the effects that gravity would have on a projectile launched in reduced and hyper gravity. They will measure the distance of the various ball bearings launched at different forces and launch angles.

Experiment Three: Fluids in Microgravity

Student and educators will observe what happens in a microgravity environment when a cork is placed in a closed container filled with a fluid and if water and oil will mix. We will test common masses in different fluids with different viscosities and time how long it takes the mass to reach the bottom of the container in 0g and hyper g. Students will need to figure out the unknown masses from the data collected in the classroom.

Amos Hiatt Middle School: Des Moines, Iowa

Amos Hiatt Middle School is a public school in Des Moines, Iowa, and has 617 students in grade. Six–eight team members include Joni Armstrong, Natalie Francis, and Mishelle Johnson.

Jon. Armstrong teaches sixth grade literacy. She graduated from Iowa State University with a degree in elementary and special education. Mrs. Armstrong completed her master's in Reading at Viterbo. Natalie Francis has been teaching math in the Des Moines Public Schools for 16 years. She has been involved with the NASA Explorer School Program for five years. Mishelle Johnson teaches eighth grade literacy. She graduated from Simpson College with a degree in elementary education with an emphasis in reading. Mishelle completed her master's degree at Drake University in Education.

Hiatt's goal is to inspire our students to "Dare to Dream." We are currently implementing our Reduced Gravity Education Flight Program in our after-school programs to motivate students to pursue activities and careers in STEM related fields. Our team and the after-school NASA club will become ambassadors for the program and promote NASA related activities in all classrooms and the community.

Charles T. Kranz Intermediate School: El Monte, California

Charles T. Kranz Intermediate School is located in Southern California in the city of El Monte. We have over 1000 students currently enrolled. Our team consists of Haile Ucbagaber, Alice Shum, and Patricia Herrera.

Alice is a native Californian and has been an educator for over 29 years. She has taught math, computer literacy, robotics, life & physical science, language arts, and fifth grade. She loves to learn new things and has a few graduate degrees. Patricia is a middle school special education teacher with 15 years of teaching experience. Currently she is coaching SRLA (Students Run Los Angeles). She is preparing students to discipline themselves for the LA Marathon. Haile has taught in the middle school for many years. He currently teaches algebra I and physical science in eighth grade. This year he will be graduating from NASA Endeavor Program with emphasis on STEM education.

The three experiments we are currently working on are well suited for what we are currently teaching in the eighth grade. We plan to invite our colleagues to join us in replicating our experiments to future classes posing questions about how the experiment would work in reduced gravity, then comparing our reduced gravity flight results with on earth data. We plan on videotaping our flight experiment to share with our students.

East Hartford-Glastonbury Magnet School (EHGEMS): East Hartford, Connecticut

EHGEMS is an inter-district magnet school for children in kindergarten through fifth grade focused on science and technology. Team members include Donna Rand, Hiroe Vestergaard, and Terry Wilson.

Donna Rand is a science teacher with 30 years of teaching experience. She has a master's degree in Gifted Education with a concentration in science. Donna has a passion for getting young children interested in science. Hiroe Vestergaard is a technology specialist with a master's degree in elementary education with 15 years of teaching experience. Hiroe has an interest in helping children use emerging technology in interesting ways to communicate their ideas. Terry Wilson is a fifth-grade teacher with a master's degree and a strong desire to bring the excitement of space exploration into the classroom to facilitate learning.

The EHGEMS Microgravity Team has designed a plan to involve every student in the school, families, and the whole community in the project. The plan includes training fifth grade students to become Microgravity Team Leaders, who in turn will teach younger children. The Microgravity Project Team will also demonstrate experimental results at our EHGEMS Family Science Night. In addition, students have been invited to present their work at Space Expo attended by hundreds at the New England Air and Space Museum in the spring.

Ellen Ochoa Learning Center: Cudahy, California

Ellen Ochoa Learning Center is located in the cities of Bell and Cudahy, Calif. and is a kindergarten – eighth grade school that operates on a 90 day/30 day, four track calendar, to reduce the effects of overcrowding.

The Reduced Gravity Team is comprised of three middle school teachers. The first member, Leticia Ortega has been teaching for 13 years. Her teaching experience includes English as a Second Language, computer science I and II, pre-algebra, algebra I and II, and geometry, as well as eighth grade Physical Science. The second team member is Kathryn Stevens. Kathryn has a degree in biology, and teaching is her second career. She has been teaching middle school math and science for the last 20 years. She loves project based learning. Juliet Kovach-Ham has a degree in chemistry and has been teaching for the last 22 years. For the past five years she has been enjoying teaching sixth grade math and science.

Our team plans to incorporate the reduced gravity experience, and its experiments, into the eighth grade physical science and sixth grade Earth science curriculum as they are a perfect match for our California State Standards (Science Framework). In addition, students will participate in discussions with students from other schools and get the opportunity to meet people with careers that include STEM backgrounds.

Ferndale Middle School: High Point, North Carolina

Ferndale is a sixth through eighth grade middle school which currently serves approximately 900 students. Three years ago Ferndale Middle School qualified as an International Baccalaureate World School. Team members include Betsy Montgomery, Krista A. Hannah, and Kimberly Forbes.

Betsy Montgomery is a sixth grade science teacher and has been teaching middle school science for six years. Betsy has a BA in Earth Science from University of North Carolina at Greensboro and approaches teaching by applying a real world practical perspective to science concepts. Krista A. Hannah is a sixth grade math teacher and has been teaching for 13 years for Guilford County Schools. She earned her bachelor's degree from the University of North Carolina at Greensboro and is currently working on a master's degree in middle grades math from Western Governor's University. Kimberly Forbes is a sixth-eighth grade technology engineering design teacher and has been teaching technology for seven years. Kimberly has a BS degree in business from Guilford College and a Masters of Art in Teaching from North Carolina A&T State University.

Our teacher team, as well as students, is excited about this extraordinary opportunity. During the experiments students have been engaged and responsive. It has given our teacher team additional opportunities to collaborate to support the STEM initiatives in our school. We believe that these lessons and experiments are sustainable and that we will be able to use them for future classes. We will also hope to be able to share these resources with colleagues in our school and throughout our district.

Forest Lake Elementary Technology Magnet School: Columbia, South Carolina

Forest Lake Elementary Technology Magnet School is located in Columbia, SC. The school services 625 students in kindergarten through fifth grade. The school provides a technology infused integrated curriculum that demands academic excellence, encourages positive self-esteem, and promotes responsible citizenship and respect for others.

Tammy Lundy teaches fifth grade math and science. She has a Bachelor of Science in Biology, a Bachelor of Arts in Elementary Education, and a master's degree in technology in education. She has been teaching for 15 years. Denise Duke teaches all content in first grade and is currently Forest Lake's Teacher of the Year. She has her Bachelor of Art in Education from the University of South Carolina and her Master's of Education from Columbia College. She has been teaching for 20 years. Rebecca Steurrys teaches fifth grade math and science. She has a bachelor's degree in elementary education and a master's degree in curriculum and instruction with a focus on Technology. She has been teaching for 11 years.

Educators from Forest Lake experience weightlessness on the aircraft.

Our team is constantly seeking out new opportunities to enrich our already challenging curriculum. We feel that the Reduced Gravity experience will show the students how everyone should continue their quest for knowledge. This collaboration with our school and NASA will heighten the students' interest to pursue STEM-G related careers and/or opportunities.

Franke Park Elementary: Fort Wayne, Indiana

Franke Park Elementary School in Fort Wayne, Ind. has a student enrollment of 600 students. They have been involved with the NASA Exploratory program since 2004. Team members include Pam Ghaffarian, Mary Roush, and Cassie Doud.

Pam Ghaffarian has a MS in Elementary Education. She has been teaching for thirteen years, 10 being at Franke Park. Mary Roush has a MS in Elementary Education. She has been teaching for thirteen years, two of them at Franke Park. Cassie Doud is in her first year at Franke Park. She has her BS in Elementary Education and loves to incorporate science into her classroom.

The Franke Park Elementary team have all been extremely excited about the opportunity to be a part of the Reduced Gravity Education Flight Program. Mary and Pam went into classrooms to discuss and perform the lessons and experiments with the teachers and students. They connected the lessons and experiments to the Indiana State Standards. In the future, we are hoping to have one of the classes submit their experiment and results to try for a place in the student symposium.

Jamestown High School: Jamestown, Pennsylvania

Jamestown High School is a small rural school. We are situated in Northwest Pennsylvania and we graduate about 50 students each year. Our three educators are Dale Anderson, Pat Mastrian, and Harry Rohrbacher.

Dale Anderson received a BS in Chemistry from Penn State ('81), Chemistry Certification from Edinboro, PA ('88), and Physics certification from Slippery Rock, PA (98). He has taught for 22 years. Pat Mastrian received a certification in Biology and General Science from Clarion, PA ('79) and his master's degree and elementary ed certification from Westminster College, PA ('82). He has taught at JHS for 32 years. Harry Rohrbacher has received a BS from Penn State, '79; an MBA, Pittsburgh, '80; and M. Ed., Biology, Slippery Rock, '05. He has taught for six years.

We are excited about using our microgravity experience to stimulate students' interest and to create additional inquiry activities for our curriculum. We will apply the concepts across all the subjects we teach. We plan to increase our involvement with NES activities, not only for what they can offer to students, but also in the hope of getting more opportunities like the reduced gravity experience to boost students' imagination.

Johnston Middle School: Houston, Texas

Johnston Middle School is a National Blue Ribbon School and a TEA Recognized campus in Houston ISD. We are a diverse inner-city campus excelling in a variety of areas with national recognition in many. Team members include Cynthia Dinneen, Amber Pinchback, and Lanena Berry.

Cynthia Dinneen has a BS from the University of Houston in Home Economics and a master's degree in library and information science. She is passionate about the role reading plays in helping all students achieve their potential, especially in the area of STEM education. She also focuses on STEM in her two specialized classes and mentors individual students with STEM research and outreach. Amber Pinchback graduated from Texas A&M with a BS in Interdisciplinary Studies and a Master's of Education in Educational Leadership. She is a teacher, a dean of science instruction, as well as a vital coordinator of school wide STEM events. Lanena Berry has a Bachelor of Science in Kinesiology from Sam Houston State University a Master's of Gifted and Talented Education from University of Houston. She is the AVID teacher (Advancement Via Individual Determination) providing instruction in all academic areas with a particular focus on STEM outreach.

Our team is dedicated to providing our students with real-world STEM applications for all our students. Our participation in NASA education events and lessons has been a catalyst on our campus for more and more involvement in STEM education. Last year, this particular focus on space science started with a live downlink with ISS 24 in September of 2010, continued with NES/MAS lessons and participation in the NES Student Symposium, and culminated with a visit by Shannon Walker and our dedication of our science wing as: "The Shannon Walker Science Satellite." We are actively involved with NCESSE and their Student Spaceflight Experiments Program as well as the Reduced Gravity Education Flight Program. We work this hard for one reason: the effect it has on our kids at JMS!

Key Peninsula Middle School: Lakebay, Washington

Key Peninsula is one of four middle schools in the Peninsula School District in Gig Harbor Washington. We have been an active participant in the NASA Explorer School program since being selected in 2004. Team members include Chris Bronstad, Kathleen Tucker-Patton, and Ron Stark.

Educator from Key Peninsula measures time on a stopwatch while in microgravity.

Chris Bronstad is currently a sixth grade Earth science teacher and visual arts teacher. Chris has been very involved in NASA Explorer School activities over the past seven years volunteering and working with students and family members at NASA family nights on various hands on science inquiry and art projects. Kathleen Tucker-Patton has been at KPMS for 10 years as a member of the NASA team and the Family Night Coordinator. Currently she teaches Title I math support classes. Ron Stark has been an educator since 1973, first in the Peace Corps, then at Zoos and Aquariums for 13 years and the remainder with Peninsula School District. Ron was a part of the original Key Peninsula NASA Explorer School leadership team for five years.

The Aerospace elective class (seventh/eighth grade) and Mission Specialist (sixth grade) class will complete the ground-based experiments. In addition, the 8th grade science classes are very much aligned with the content of the reduced gravity experiments and will also complete trials. The reduced gravity experience will be highlighted during our next NASA Family Night with an overview and hands-on activities for families. Selected students will complete write-ups after the flight and will apply to competitive symposia for presentation and communication of results.

Lakewood High School: Lakewood, California

Lakewood is one of eight high schools in the Long Beach Unified School District. We are considered an urban school located in the suburban area of Lakewood California. Lakewood has an enrollment of over 4,200 students in grades nine-12. Team members include Keith Miller, Lindsay Bobo, and Russell "Myles" Loveall.

Keith Miller is a National Board Certified Teacher in science. He has taught courses in anthropology, biology, life science, chemistry, marine biology, Physical/Earth Science, physical oceanography, and AP environmental science at Lakewood High School in the Long Beach USD for the past 26 years. He has been a member of Lakewood's NES Team since 2004. Lindsay Bobo is a Nationally Board Certified teacher. She has been teaching in the Applied Technology Magnet (ATM) Program at Lakewood High School for eight years teaching subjects such as geoscience, AP biology, and biology. She has been a member of the NES Team since 2005. Russell "Myles" Loveall has been teaching for 15 years in subjects such as geoscience, physical science, biology, AP physics and physics. He was the primary writer on the NASA Explorer School (NES) grant in 2004 and the team leader for Lakewood's NES Team.

The Lakewood team conducts cross curricular projects throughout the year all of which utilize NASA STEM resources. In the future, we plan on adding to our year long Rocket Project to include one of our Reduced Gravity experiments. We are also hoping to get some film clips of our team to emphasize subject to be used in our physics class.

Mack Benn Jr. Elementary School: Suffolk, Virginia

Mack Benn, Jr. Elementary School is a Title 1, PreK-5 school located in Suffolk, VA. Due to our proximity to several military bases, many of our students and staff have one or more family members serving our country. Team members include Elizabeth Petry, Megan Farabaugh, and Catherine Pichon.

Elizabeth Petry has a bachelor's degree in music education, a Master's of Science in Literacy and Culture, and a gifted education endorsement. She currently serves as a gifted resource teacher for students in grades 1-5, and has been teaching for 15 years. Megan Farabaugh has a bachelor's degree in elementary education Pre-K to sixth, a master's degree in education and a gifted education endorsement. Ms. Farabaugh is currently a second-grade teacher and she is in her seventh year of teaching. Catherine Pichon has a bachelor's degree in Interdisciplinary Studies, and she is currently in graduate school at Regent University. She has 11 years teaching experience in grades three-six.

Mack Benn, Jr. Elementary school became a NASA Explorer School in September 2010. As part of the NES program, we participated in a number of video conferences and utilized many of the teaching resources available through NES. We are working to share more STEM activities with our students to increase their conceptual understanding of science and math, not only within the school setting, but how to apply their knowledge to authentic learning opportunities. We are trying to incorporate the experiments and/or concepts involved in them into everything we are doing; we even found a way to tie it into our math enrichment groups. We were very fortunate to have two students selected to participate in the Student Symposium last year, and we are currently working to facilitate our students as they prepare presentations for the 2012 Virtual Symposium. We hope to make this a tradition at our school.

St. Mary's Visitation School: Elm Grove, Wisconsin

St. Mary's Visitation School, in Elm Grove, Wis., is a Catholic school which celebrated its 150th anniversary in 2009. Our curricula and assessment procedures are aligned with the Archdiocesan curricular initiatives and the Wisconsin state standards. Team members include Kathy Biernat, Kylie Daemmrich, and Michael Falk.

Kathy Biernat is in her eighth year of teaching, and her sixth year of teaching science in the junior high at SMV. She holds a bachelor's degree from Marquette University and master's degree in education from the University of North Texas. Kylie Daemmrich is in her fifth year of teaching and her fourth year at SMV and teaches fourth graders in all content areas but her favorite is math. In 2007, Kylie earned a Bachelor of Science in Elementary Education from Cardinal Stritch University and went on to complete a Master of Education in Instructional Technology there in 2011. Michael Falk is in his fifth year of teaching mathematics and his second year of teaching junior high students at St. Mary's Visitation. He holds bachelor's and master's degrees in meteorology from Iowa State University and a teaching certification from the University of Wisconsin Milwaukee.

Our application for the Reduced Gravity Education Flight began as a bit of a lark that has grown into a real opportunity for us to collaborate on teaching children across grade levels and subject areas. This opportunity gives us a template for working together towards our goals of preparing children for the real life challenges of problem solving, hypothesis testing and analysis of data.

Woodrow Wilson Middle School: Glendale, California

Woodrow Wilson Middle School in Glendale, Calif., has been a Distinguished School in California for three years. Wilson Middle School is a Title 1 school that serves a diverse socio-economic student population. Team members include Mary Inglish, Polly Jackson, and Paul Gersten.

Mary Inglish earned her BS in biological sciences and a minor in psychology from University of California, Irvine in 1994. She is currently teaching eighth grade physical science however she has taught middle school science to grades six and seven over the past 12 years. Polly Jackson received her BA in math in 2004 and her MA in math education in 2009, both at California State University, Northridge. She has taught middle school math for the past eight years. Paul Gersten graduated Baruch College, in New York City, in 1966, receiving his BBA. In 2002, he graduated Pacific Oaks College and earned his MA in reading and literacy. For the past four years he has been teaching sixth grade math and science.

Our team is extremely excited about the reduced gravity flight experience as a way of showing our students, first hand, the effects of gravity on our everyday lives. We plan to implement this experience into our curriculum and cross-curricular activities. This is a great augmentation to our MESA (Math Engineering Science Achievement) and Robotics programs in which our students are participating. We plan to use these experiments and videos of the weightless flight in our current and future lessons.

Pre-Service Teacher Institute: Houston, Texas

The Reduced Gravity Education Flight Program has teamed with the NASA Pre-service Teacher Institute (PSTI) to provide a one of a kind flight experience. The flight opportunity is a unique academic experience for teachers (current and past PSTI participants) to successfully fly and evaluate two reduced gravity investigations.

Amber Bright will be teaching fifth and sixth grade science at Gregory-Portland Intermediate School this Fall. She began her teaching career this past January teaching sixth grade math after completing her bachelor's degree in interdisciplinary studies at Texas A&M University-Corpus Christi in December of 2011.

JoAnn Isonhood teaches sixth grade math and science at Hoover Middle School in Albuquerque, N. M. She graduated from University of NM with her BS in elementary education with a concentration in science and endorsed in English as a Second Language. JoAnn has been teaching sixth-eighth grade math and sixth grade science for three years. She has been apart of the PSTI program since she attended it in 2009 and has facilitated every summer since then. She also holds math tutoring and has a girl club called G.E.M.S. (Girls Empowered in Middle School). JoAnn's goal is to help students find their passion in middle school and follow their dreams.

Veronica Koite teaches sixth grade math, and has been in the classroom for three years. Veronica graduated from Texas A&M University with a degree in Interdisciplinary Studies, specifically math and science education for grades four-eight, and will begin working on her Master of Education in Curriculum and Instruction Mathematics Education this Fall. Veronica will be implementing the Reduced Gravity Flight Education Program activities through an after school science and math club at Sam Rayburn Middle School in Bryan, Texas.

Maggie Piepenbrink teaches fourth grade. Hanby Elementary is a public school just outside of Dallas, TX with 881 students in Pre-K through fifth grade. Hanby is a Title I Exemplary school. She graduated from Texas A&M University in College Station with a degree in interdisciplinary studies. Piepenbrink is a supporter of creativity and fun in the classroom, and the NASA activities she has learned help her in fulfilling those aspects.

Allison Stalker graduated from University of Wisconsin-Eau Claire in May. She graduated with a degree in elementary education with a minor in general science. Allison had her second placement for student teaching at Sherman Elementary School in fourth grade. Allison has incorporated some of the activities learned at NASA's Pre-Service Teacher Institute at her summer camp job.

Appendixes

Top, left: Educators from Forest Lake Elementary are taking data in flight while astronaut Dottie Metcalf-Lindenberger looks on.

Middle, left: HUNCH student takes data in flight.

Bottom, left: Students from Lamar University pose for a team photo prior to flight.

Top, right: Participant experience the weightless environment.

Middle, right: Participant gives the thumbs up as he floats in microgravity.

Right, bottom: Associate Administrator Leland Melvin does push-ups in partial gravity.

Appendix 1 – Proposals at a Glance

Undergraduate Student Program

Selected Engineering Proposals

Institution	Proposal Title	Page
Massachusetts Institute of Technology	Human-Mediated Testing of Guidance, Navigation and Control for Hopping/Landing Vehicles in the Neighborhood of a Near-Earth Object	8
Purdue University	Exploration of Capillary Fluid Transition in Microgravity	8
University of Florida	Turbulent Liquid Helium Childown of a Pipe under Microgravity and Terrestrial Conditions	9
University of Southern California	The Effect of the Radiative Properties of Gases on Combustion Behavior in a Microgravity Environment	10
University of Texas at El Paso	Combustion Mechanisms of Lunar Regolith/Magnesium Mixtures	10
University of Washington	Centrifugal Method for Particle Size Segregation	10
Utah State University	FUNBOE 2.5, Follow-Up Nucleate Boiling On-Flight Experiment	11
Virginia Polytechnic Institute & State University	Internal Linear Actuator Satellite Attitude Control	11
West Virginia University	Electrostatically Enhanced Fluidized Bed in Microgravity	11

Selected Physical Science Proposals

Institution	Proposal Title	Page
Arizona State University	Dust Coagulation in Microgravity	6
Bryn Mawr College	Determining the Porosity of Martian Soil Simulant in Microgravity	7
Delaware Technical & Community College	Vertical Projectile Motion with Drag in 1g and 0g Environments	7
Lamar University	Wave Dispersion on a Torsion Wave Machine in Accelerated Reference Frames	7
Santa Ana College	Nanostructured Metallic Foams Created through Self-Propagating High Temperature Synthesis	9
University of Colorado at Boulder	Validating the Gravity Dependence of the Churchill-Chu Correlation for Free Convective Heat Transfer from a Finite, Flat Plate	9
Yale University	On the Behavior of Two-Dimensional Rayleigh-Taylor Instability in Various Gravities	12

Selected Life Science (Including Biology) Proposal

Institution	Proposal Title	Page
Boise State University	Calcium Flux in Osteocytes and Osteoblasts Due to Gravitational Manipulation	6
Missouri University of Science & Technology	Microgravity Testing of ACD-CPR Device	8

SEED Program

Selected Proposals

Institution	Proposal Title	Page
Carthage College	Fluid Vessel Quantity Using Non-Invasive PZT Technology Phase 2	13
Georgia Institute of Technology	Suitport Alignment in Microgravity	13
Northwest Nazarene University	Superhydrophobic Phase Separation in Microgravity	13
Oklahoma State University	Techniques for Motion Analysis in Reduced Gravity	14
University of Houston-Clear Lake and San Jacinto College	Robotic Control using Gesture and Voice	14
University of Illinois at Urbana/Champaign	Human Systems Integration of Tablet Computing	14
University of Nebraska-Lincoln	Flame Behavior of a MEMS-GC Detector	15
University of Wisconsin at Madison	Space Suit Dust Removal Techniques in Reduced Gravity	15
Washington University in St. Louis	Development of Feed Water Supply Assembly for Spacesuit Cooling	15

HUNCH Program

Selected Proposals

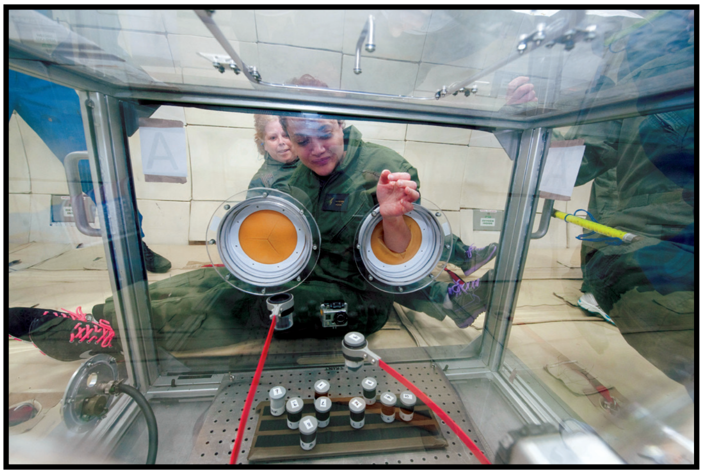
Institution	Proposal Title	Page
Clear Springs High School	Food Growth Chamber	16
East High School	Dispersion of Scents in Microgravity	16
Lakewood High School	Hydrofuge Plant Growth Chamber for ISS	16
North Carolina School of Science and Mathematics	Spinal Compression Model	17
Overland High School	Microgravity Water Purification System	17
Warren Tech Career Center	Frying an Egg in Space	17
Warren Tech Central Campus	Aquaponics System on the ISS	17

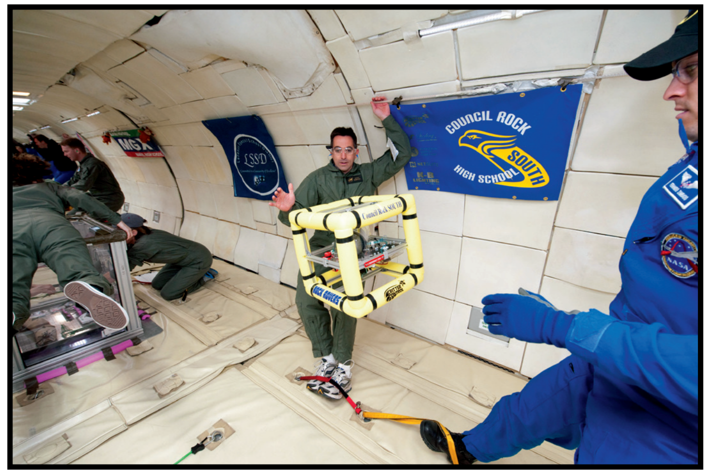
Microgravity eXperience (Teaching From Space) Program

Selected Proposals

Institution	Proposal Title	Page
Council Rock High School - South	Remotely Operated 0G Vehicle	18
Eastern Elementary School	Electron Flow in Zero Gravity	18
Einstein Fellows	Diffusion in Microgravity	19
Glacier High School	Oxygen Generation at Zero G	19
Lebanon Special School District	Sutures in Space	19
Target Range and Anna Jeffries School	Liquid Layers in Microgravity	20
Warren Consolidated Schools	Convection Current Formation in a Micro-G Environment	20

Appendix 2 – Demographic Data





Top, left: Educator works with interia balance experiment on microgravity aircraft.

Middle, left: Students from Georgia Institute of Technology make adjustments to their hardware prior to flight.

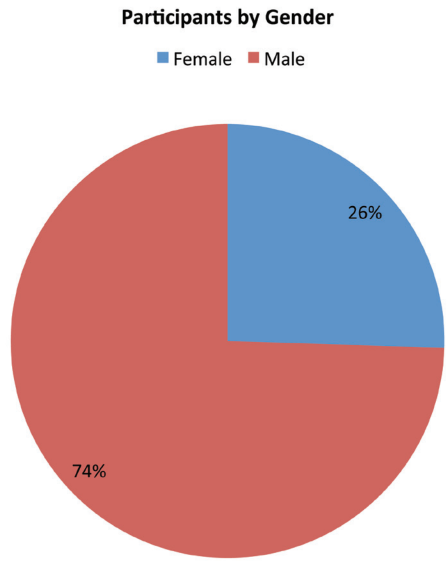
Bottom, left: Students from University of Texas at El paso monitor experiment during the flight.

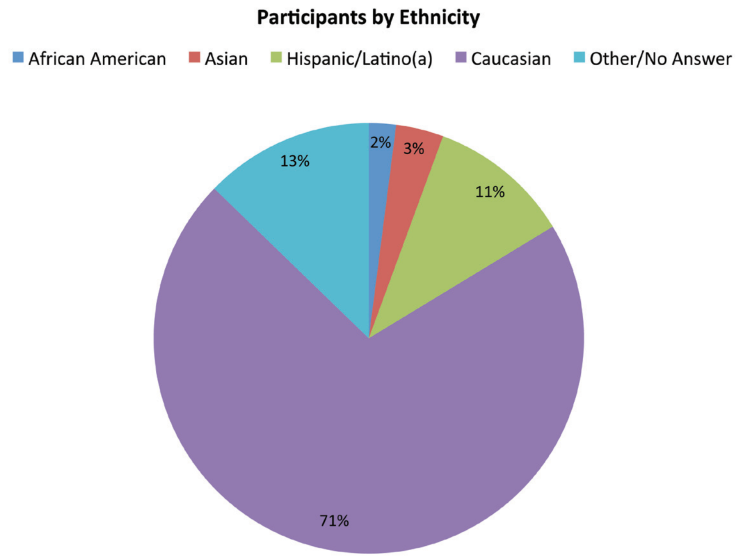
Top, right: Educators from Council Rock High School South deploy their free-float experiment.

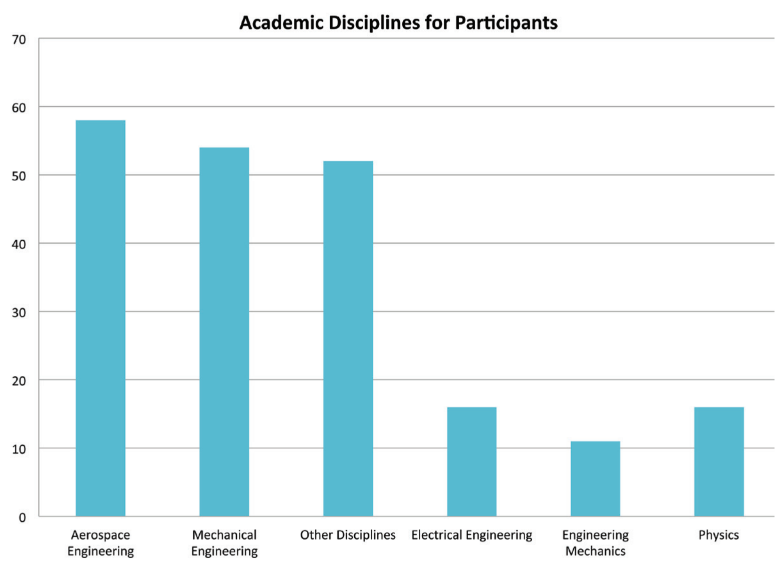
Middle, right: University of Illinois students work with their experiment in microgravity.

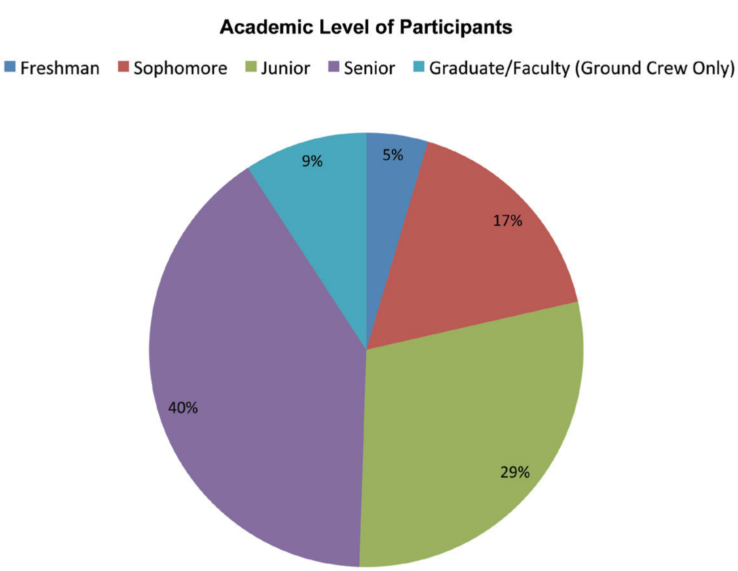
Bottom, right: Flight team deploys their free float CubeSat during a parabola.

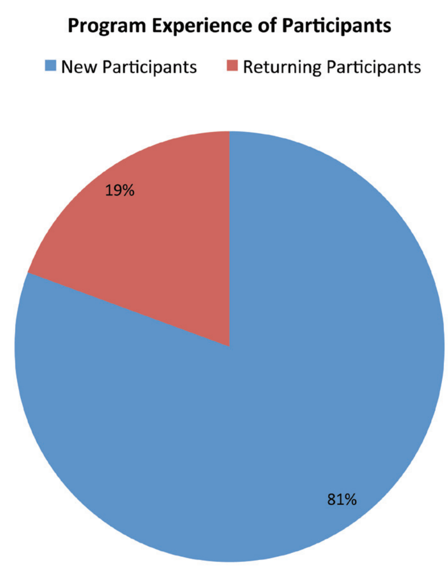
Combined Undergraduate Students Demographic Information (UGrad, SEED)



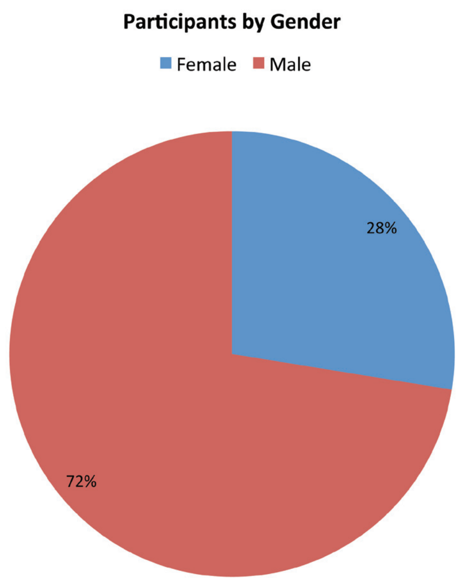


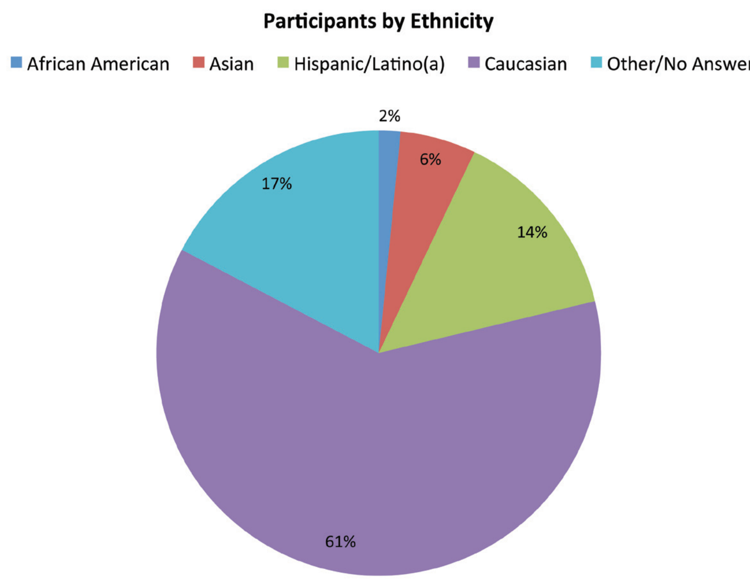


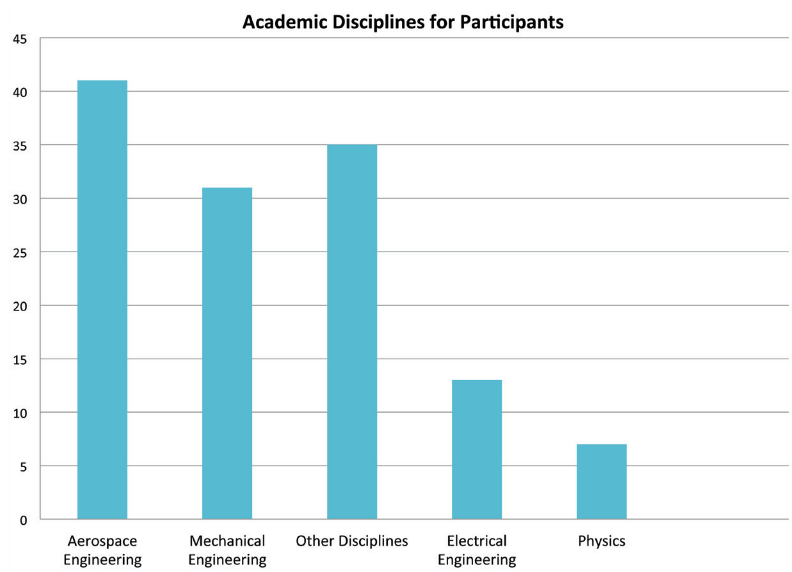


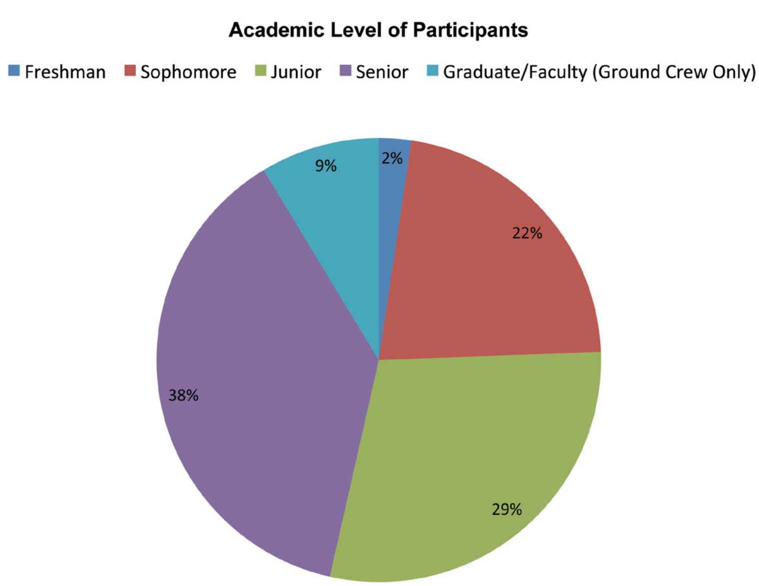


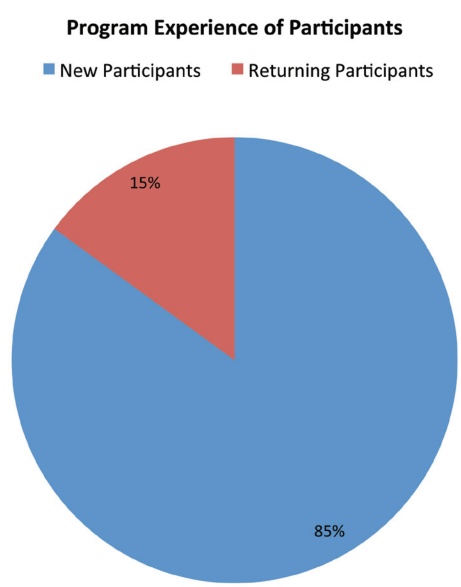
Undergraduate Student Program (UGrad) Demographic Information



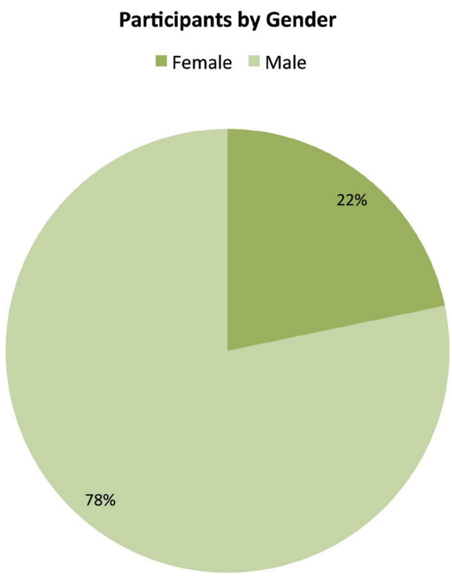


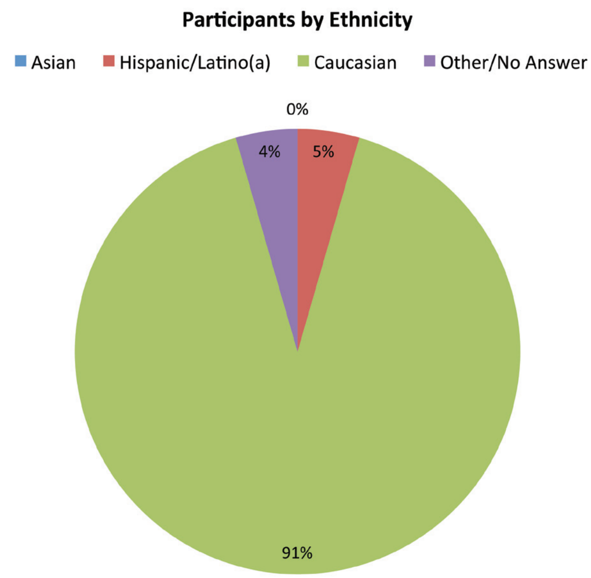


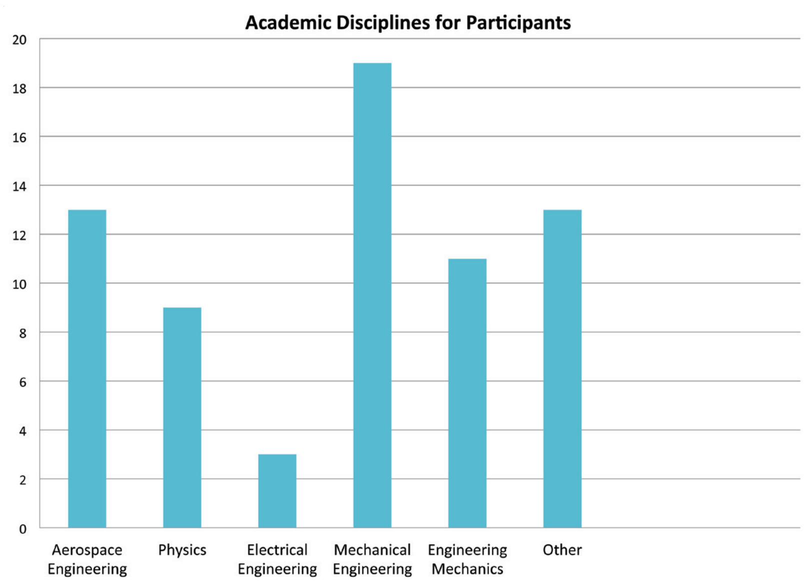


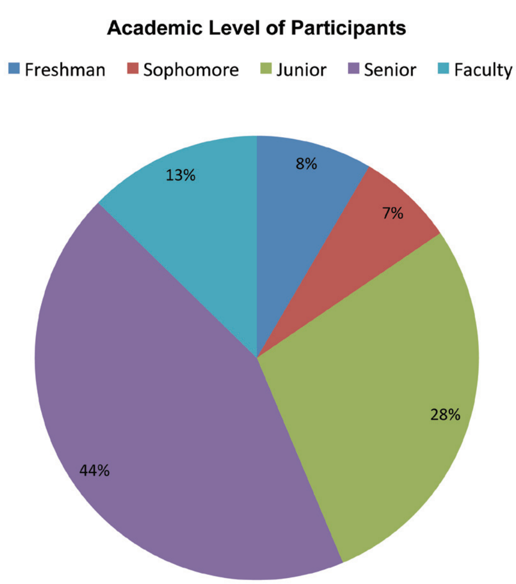


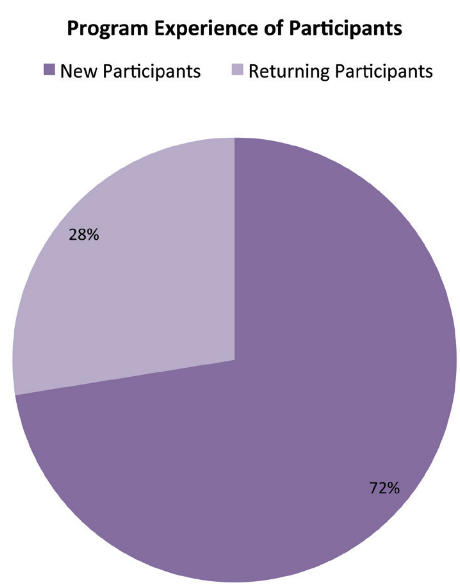
Systems Engineering Educational Discovery (SEED) Demographic Information



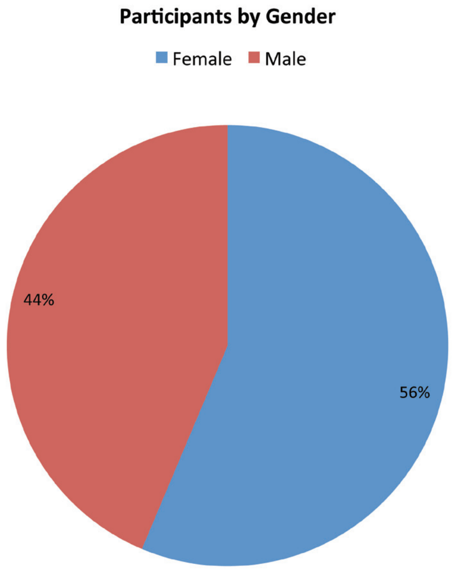


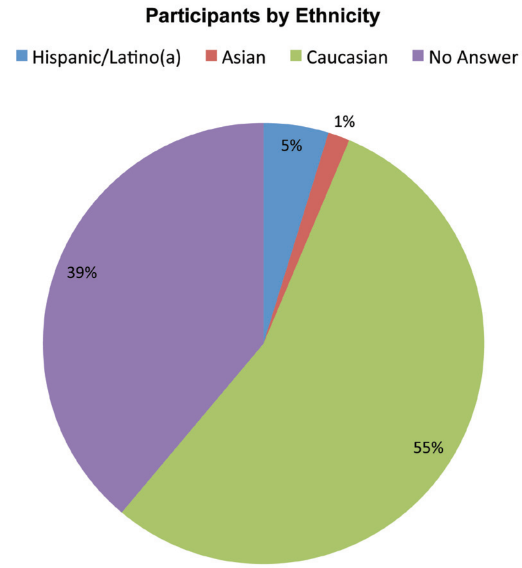


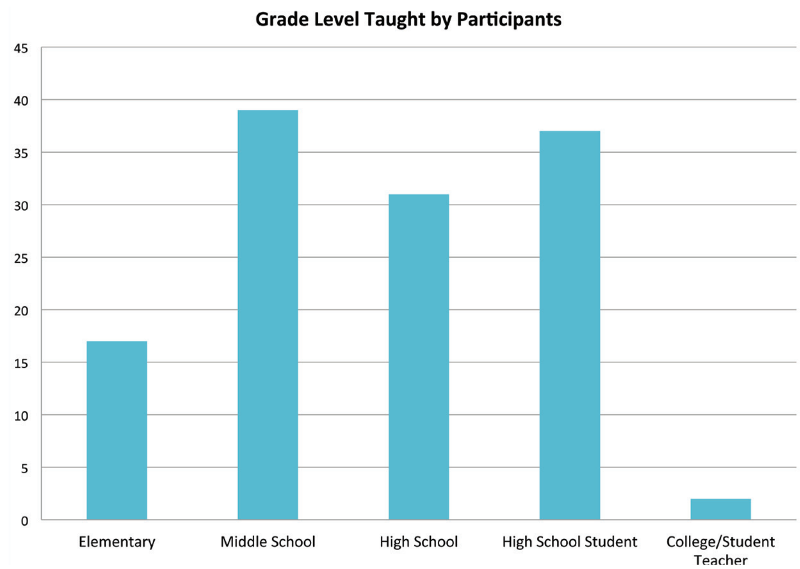


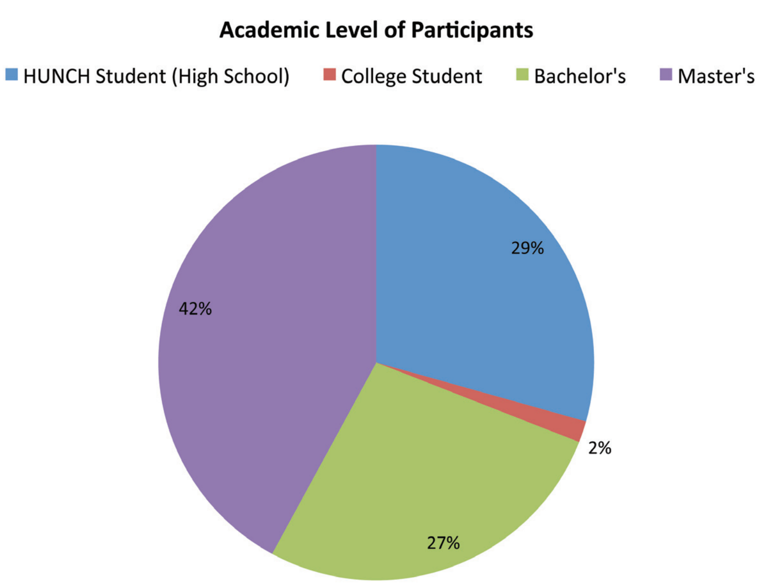


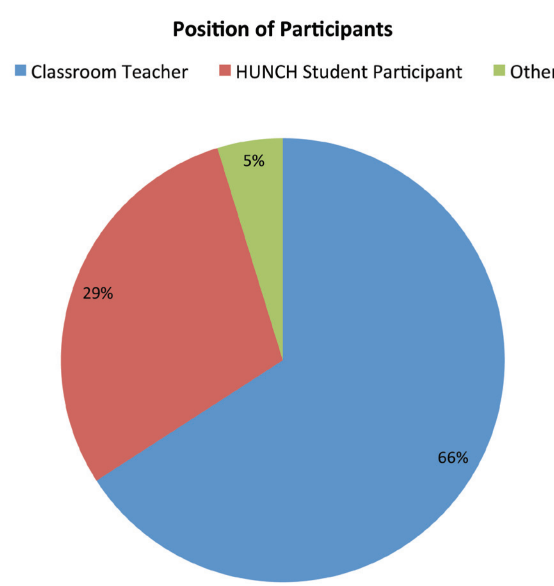
Combined K-12 Demographic Information
(HUNCH, Microgravity eXperience, NES)



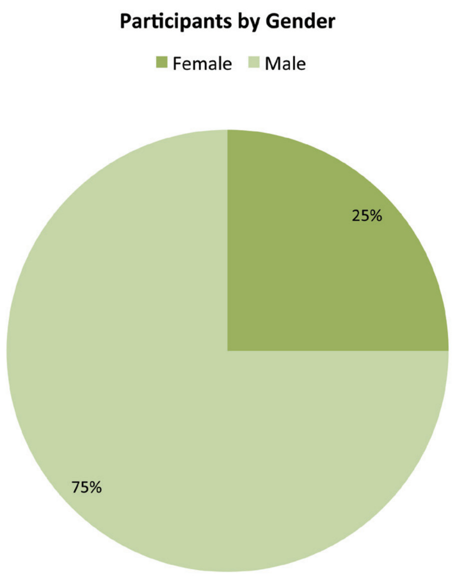


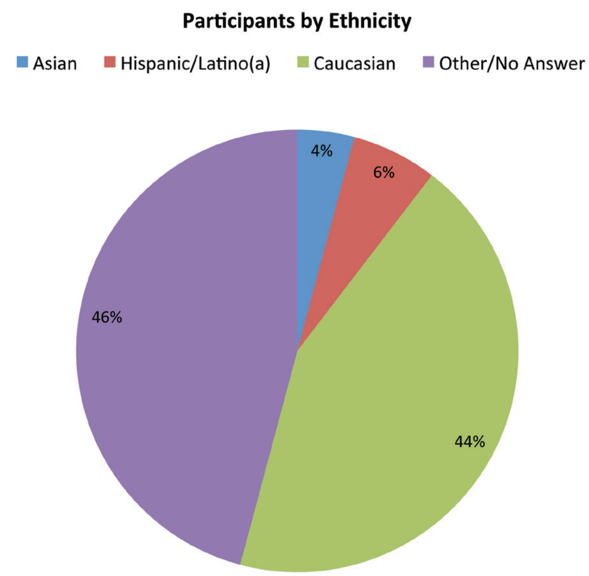


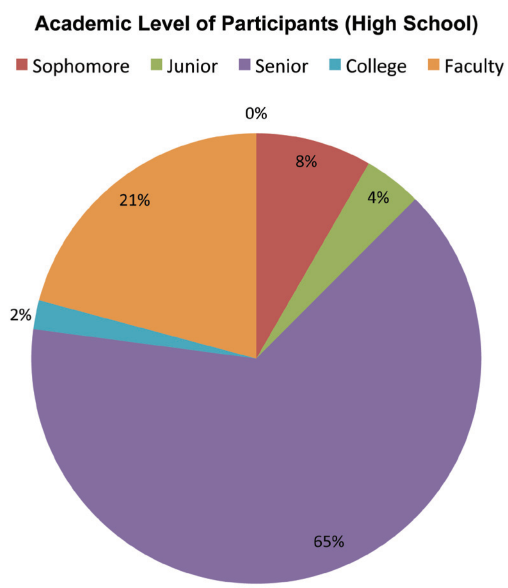


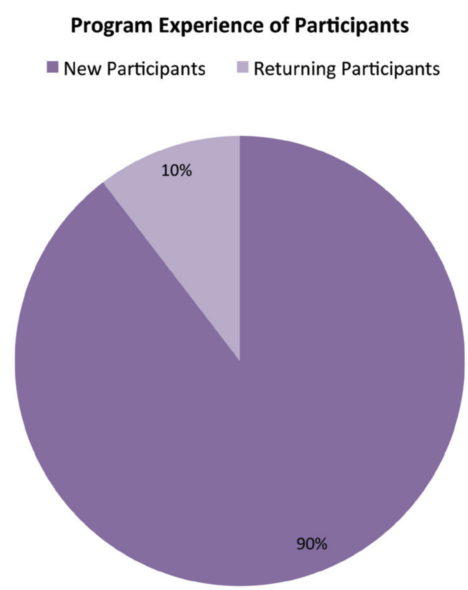


High School Students United with NASA to Create Hardware (HUNCH) Demographic Information

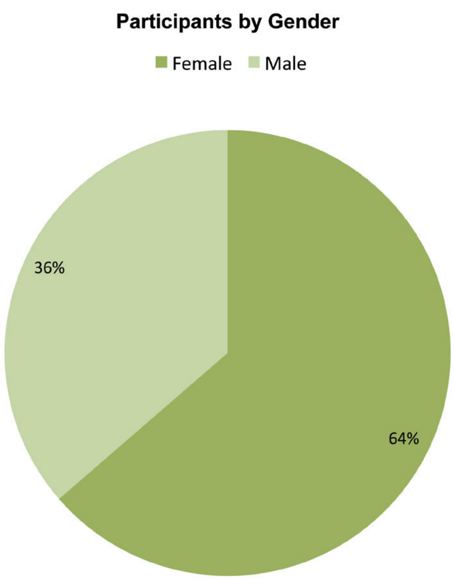


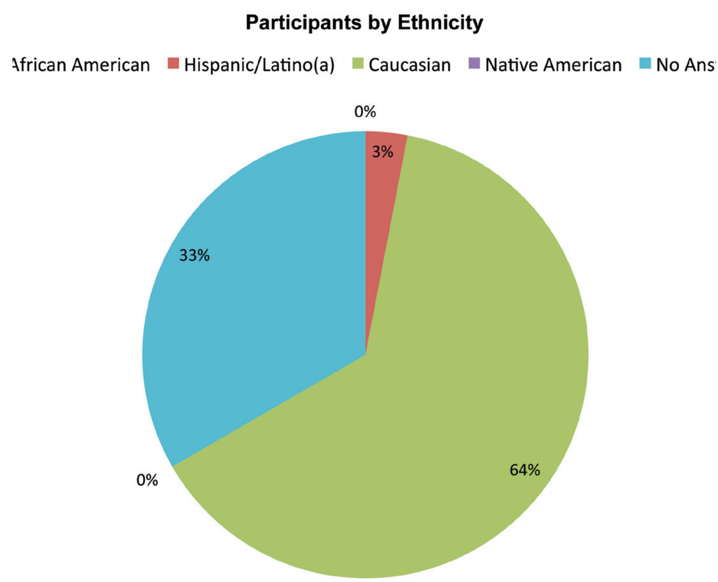


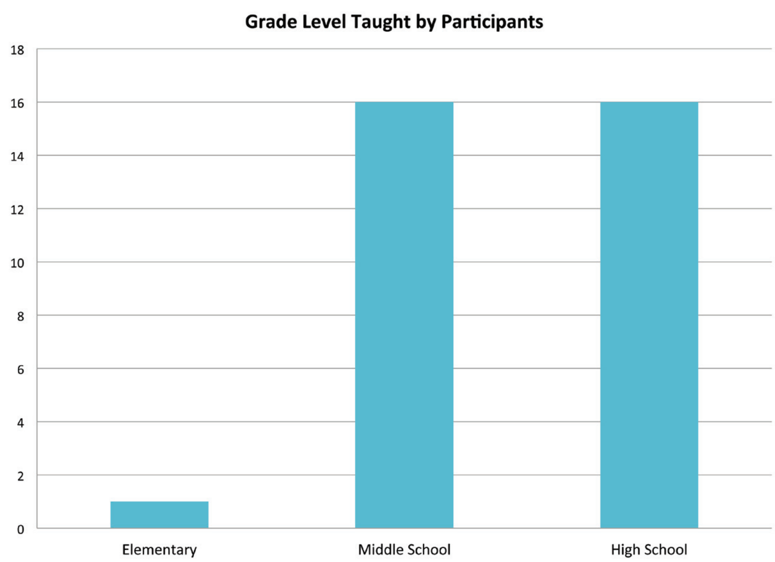


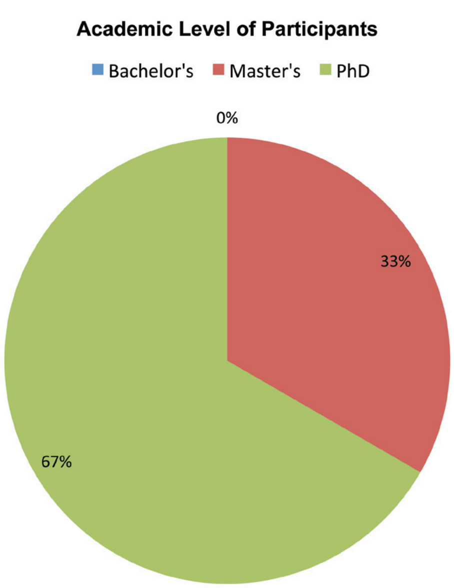


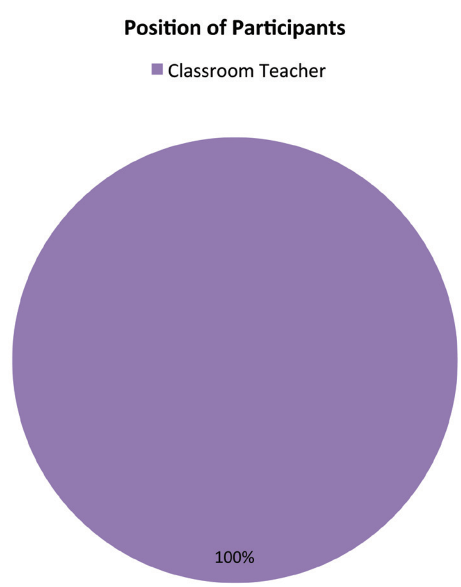
Microgravity eXperience Demographic Information



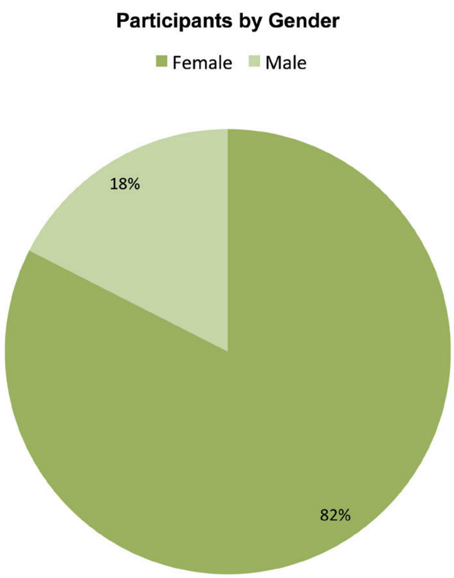


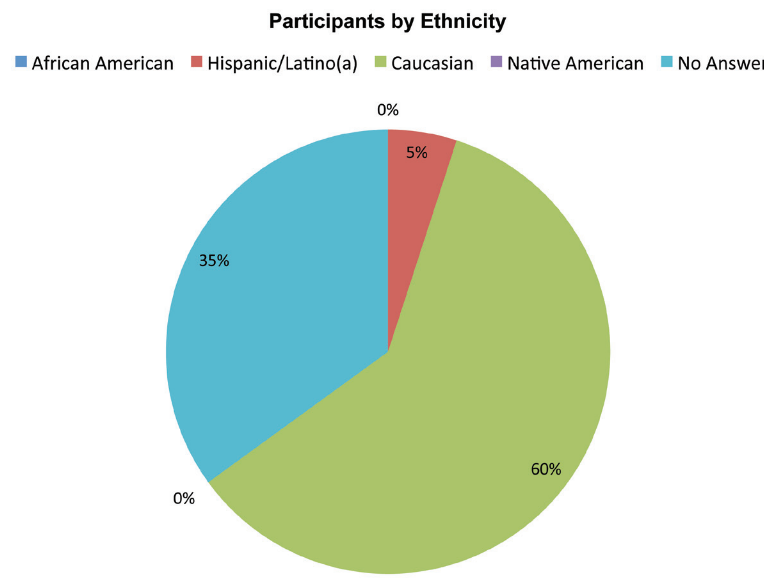


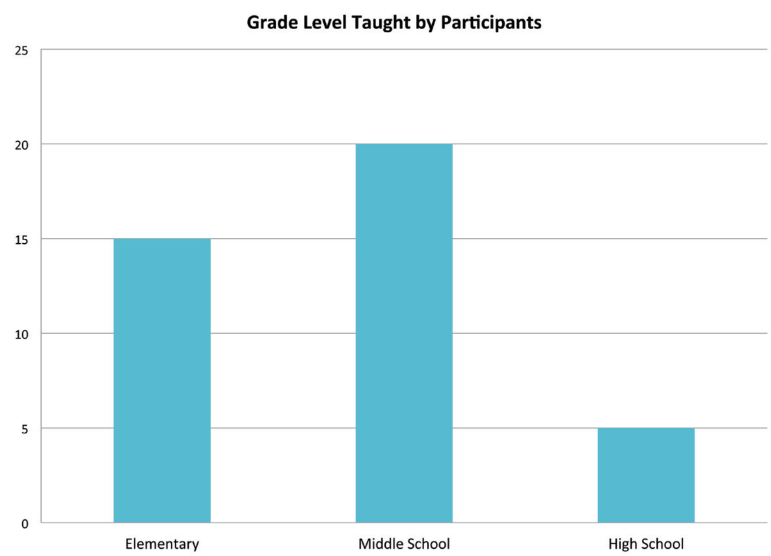


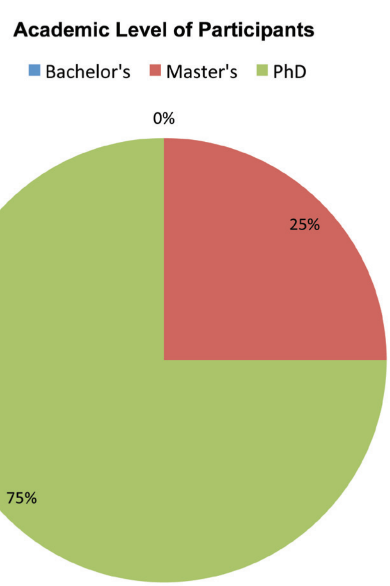


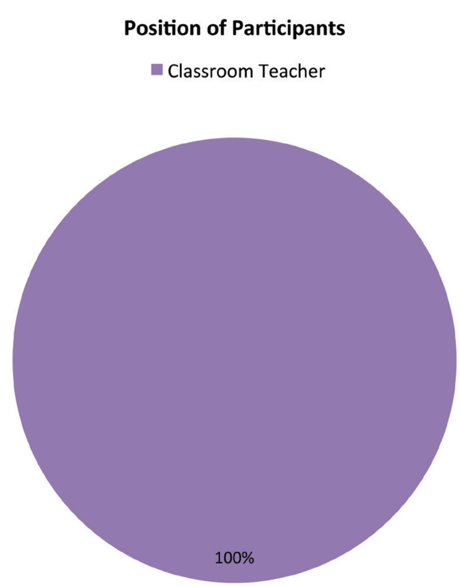
NASA Explorer Schools (NES) Demographic Information











Appendix 3 – Participant Comments

Program evaluations were collected post-flight. Educators, students, and faculty overwhelmingly praised the program for providing a rare real world hands-on engineering experience for K-12 and undergraduate students. A few of the educator and student responses follow.

- *"Thanks so much for the experience! Now I know the sky is NOT the limit and to dream big! The experience was wonderful for teaching students how to work together on a science project. I hope to do more things with NASA in the future."*
- *"In addition to the knowledge the kids are gaining and the excitement in class, I have very protective students who know that, in my mind, I am risking my life to teach them! They are not only learning about inertia, physics, living in space, microgravity, bacteria, you name it, they are learning that doing the right thing for science often involves overcoming fear. It's a mighty tight bond. They are so looking forward to the next DLN event! We may need more than 30 minutes for questions."*
- *"This is a unique 'real-life' experience for students. Students really realize the consequences of poor planning and poor work ownership. Redesigning and rebuilding were an integrated part of the experience. It either works or not and they are responsible for some. It is a life altering experience."*
- *"Participating in this program has opened my eyes to my capacity and enjoyment of applying science, technology, engineering, and mathematics. By working for a year on an interesting interdisciplinary project with my team I have gained an appreciation for the hard work, collaboration, and creative thinking that goes into research and NASA Operations. By talking to astronauts we learned of their frequent back pain and spinal elongation in space and through RGEFP we were able to design and build a model of the spine to test how it changes in microgravity. I had never imagined that I would be able to put my love of biology and engineering together in such an interesting undertaking, and the opportunity to fly zero-G and visit JSC has been an invaluable experience that will always remain among my treasured memories."*
- *"This was an excellent program, giving students the once-in-a-lifetime experience of performing scientific research in microgravity."*
- *"…the experience of participating in this program has been fantastic! Thank you so much for affording us this opportunity."*
- *"I enjoyed this experience so much. We had some issues with our experiment, but we were able to fly because everyone here at NASA helped us to improve our project. Thank you for allowing us to participate in such a rare, once in a lifetime opportunity."*

"This was without a doubt a once in a lifetime experience in multiple ways. Not only was it a ton of fun, but it offered insight into a very new field of research that I've become quite interested in."

- *"From day one every aspect of the microgravity program was informative, on-time, and professional. This is an AMAZING experience for students and instructions, expectations, scheduling, and support were all beyond my expectations. Because of my participation in the program I will be able to communicate how amazing it is to be here and better recruit future students who would be interested. I'm truly grateful to be here. Thank you!"*
- *"This was a great experience that I could only dream of happening to me. I will never forget this experience and it will change me forever."*
- *"Best experience of my life. The experience of participating in this program has been fantastic! Thank you so much for affording us this opportunity."*
- *"Thank you for providing opportunity of unforgettable experience."*
- *"This was an excellent program, giving students the once-in-a-lifetime experience of performing scientific research in microgravity."*
- *The safety and flight procedures were all covered extremely well; I felt very prepared to fly and had little to no issues during the flight. The RGO team and support staff were very good about keeping us informed about what was happening when the schedule changed due to weather delays. This was probably because of the well structured daily and flight briefings"*
- *"This was an exciting and educational week… I want to thank you all for a truly awesome experience and once in a lifetime event that may change career path."*
- *I think this is a great program and only wish there were more of them out there like this one to make this kind of experience accessible to more students with interesting research.*
- *Thank you for this amazing experience. I am so excited to bring it to my school and community! I cannot wait to teach what I've learned to my students and teachers. I know my excitement will definitely get students and others passionate about STEM! This has been a once in a lifetime experience!*

Appendix 4 – 1995-2012 Participating College and University Status

3,539 Student Flyers (does not include ground crew)

203 Institutions / 723 Teams / 50 States (plus DC & Puerto Rico)

Institution Participation:

AK	Univ of Alaska Fairbanks	CT	Yale University	MA	Harvard University
AL	Alabama A&M Univ	DC	George Washington Univ	MA	Massachusetts Inst of Tech
AL	Auburn University	DE	Delaware Technical & Community College	MA	Smith College
AL	Tuskegee University	FL	Broward CC	MA	Tufts University
AL	Univ of Alabama-Birmingham	FL	Embry-Riddle Aeronautical University	MA	Univ Massachusetts-Lowell
AL	Univ of Alabama-Huntsville	FL	Florida A&M University	MA	Wellesley College
AL	Univ of Alabama-Tuscaloosa	FL	Florida Institute of Technology	MD	Johns Hopkins University
AR	Univ of Arkansas	FL	Florida State University	MD	Montgomery County CC
AR	University of the Ozarks	FL	Palm Beach State College	MD	United States Naval Academy
AZ	Arizona State University	FL	Saint Leo College	MD	Univ of Maryland-College Park
AZ	Embry-Riddle Aeronautical Univ-Prescott	FL	State College of Florida, Manatee-Sarasota	ME	University of Southern Maine
AZ	Norther. Arizona Univ	FL	University of Florida	MI	Hope College
AZ	University of Arizona	FL	University of Miami	MI	Michigan Technological University
CA	Cal State-San Marcos	GA	Georgia Institute of Tech	MI	Univ of Michigan – Ann Arbor
CA	California Institute of Technology	GA	Morehouse School of Med.	MI	Univ of Michigan-Dearborn
CA	California Polytechnic University	GA	State Univ of West Georgia	MN	Univ of Minnesota-Minneapolis
CA	California State Polytechnic Univ, Pomona	GA	University of Georgia	MO	Drury College
CA	California State Univ, Fresno	HI	Windward Comm College	MO	Missouri Univ Sci & Tech
CA	Chapman University	IA	Iowa State University	MO	University of Missouri
CA	Citrus College	IA	University of Iowa	MO	Washington University-St. Louis
CA	Foothill College	IA	University of Northern Iowa	MS	Univ of Southern Mississippi
CA	Fullerton College	ID	Boise State University	MS	Mississippi State University
CA	Grossmont College	ID	Northwest Nazarene Univ	MT	Dull Knife Mem Tribal College
CA	Harvey Mudd College	ID	Shonshone-Bannock	MT	Montana State Univ-Billings
CA	Lake Tahoe Community College	ID	University of Idaho	MT	Montana State Univ-Bozeman
CA	Los Medanos College	IL	DePaul University	NC	Duke University
CA	Pomona College	IL	Northern Illinois University	NC	North Carolina A&T State University
CA	San Diego City College	IL	Northwestern University	NC	North Carolina State Univ
CA	San Diego State Univ	IL	Univ of Illinois-Chicago	NC	UNorth Carolina- Pembroke
CA	San Francisco Art Institute	IL	Univ of Illinois-Urbana/Champaign	NC	UNorth Carolina-Charlotte
CA	Santa Ana College	IL	William Raney Harper College	ND	North Dakota State Univ
CA	UC-Berkeley	IN	Ivy Tech CC of Indiana	ND	University of North Dakota
CA	UC-San Diego	IN	Purdue University	NE	Univ of Nebraska at Lincoln
CA	Univ of Southern California	IN	Rose-Hulman Institute	NH	Dartmouth College
CA	University of San Diego	IN	Taylor University	NJ	Atlantic Cape College
CO	CC of Aurora	KS	Pittsburg State University	NJ	College of New Jersey
CO	Colorado School of Mines	KS	University of Kansas	NJ	Princeton University
CO	Colorado State University	KS	Wichita State University	NJ	Rowan University
CO	Univ of Colorado-Boulder	KY	Eastern Kentucky University	NM	New Mexico State Univ
CO	US Air Force Academy	KY	University of Kentucky	NM	New Mexico Tech
CT	Fairfield University	LA	Louisiana State University	NM	University of New Mexico
CT	Wesleyan University	LA	Louisiana Tech University	NV	University of Nevada-Reno

NY	Alfred University	PA	University of Pittsburgh	TX	Univ of Houston-Clear Lake
NY	Cornell University	PR	Univ of Puerto Rico-Mayaguez	TX	Univ of Texas -San Antonio
NY	Fordham University	PR	Univ of Puerto Rico-Rio Piedras	TX	University of Houston
NY	Polytechnic University	RI	Brown University	TX	University of Texas -Dallas
NY	Rochester Inst of Technology	RI	Community College of Rhode Island	TX	University of Texas -El Paso
NY	State University of New York Buffalo	RI	Univ of Rhode Island	TX	University of Texas-Austin
NY	Syracus. University	SC	Clemson University	UT	Brigham Young University
NY	United States Military Academy	SC	College of Charleston	UT	University of Utah
OH	Case Western Reserve Univ	SD	South Dakota School of Mines & Technology	UT	Utah State University
OH	Ohio Northern University	TN	Rhodes College	VA	Virginia Polytechnic Institute and State College
OH	The Ohio State University	TN	Tennessee State University	VT	Norwich University
OH	University of Cincinnati	TN	Tennessee Technological University	VT	University of Vermont
OH	University of Toledo	TN	University of Tennessee	WA	Seattle Central Community College
OK	Oklahoma State University	TX	Austin Community College	WA	Seattle Pacific University
OK	University of Oklahoma	TX	Collin County Community College	WA	Seattle University
OK	University of Tulsa	TX	El Paso Community College	WA	Tacoma Community College
OR	Oregon Inst of Technology	TX	Lamar University	WA	University of Washington
OR	Oregon State University	TX	Prairie View A&M Univ	WA	Washington State University
OR	Portland State University	TX	Rice University	WI	Carthage College
OR	Western Oregon University	TX	San Jacinto College	WI	Ripon College
PA	Bryn Mawr College	TX	Stephen F. Austin State University	WI	Univ of Wisconsin-Madison
PA	Carnegie Mellon University	TX	Texas A&M University	WV	Bethany College
PA	Drexel University	TX	Texas Christian University	WV	Marshal. University
PA	Lehigh University	TX	Texas Southern University	WV	West Virginia University
PA	Penn State University	TX	Texas State University	WY	University of Wyoming
PA	University of Pennsylvania	TX	Texas Tech University		

2012 participants are highlighted in blue

Appendix 5 – 1998-2012 K12 Participating Institutions

1,282 Educator Flyers (does not include ground crew)
233 Institutions / 222 Teams / 40 States (plus Puerto Rico & Ecuador)

Institution Participation:

	Academia Cotopaxi American International School	FL	South Plantation High	NC	North Carolina School of Science and Mathematics
AL	Bob Jones High School	FL	Surfside Elementary School	NC	Northwoods Park Middle School
AL	Cary Woods Elementary	FL	The Master's Academy	NE	Pender Public School
AL	Dean Road Elementary	GA	Bear Creek Middle School	NH	Indian River School
AL	J.F. Drake Middle School	GA	Columbus High School	NH	Mascoma High School
AL	Jefferson County, Trussville City Schools	GA	Conyers Middle School	NH	Timberlane Regional High
AR	Langston Magnet Elementary	GA	Muscogee County School	NJ	Bergen County Technical Schools
AZ	Arrowhead Elementary	GA	Riverside High School	NJ	Burlington Count. Institute of Technology
AZ	Peak School & Flagstaff Unified School District	IA	Amos Hiatt Middle School	NJ	Dr. Albert Einstein Academy
CA	Alice Worsley School	IA	Harding Middle School	NJ	Dunn Middle School
CA	Charles T. Kranz Intermediate School	IA	Sioux City Community Middle School	NJ	Ewing Middle School
CA	Ellen Ochoa Learning Center	ID	Kuna High School	NJ	Gregory Elementary School
CA	Gifford C. Cole Middle School	IL	Clara Barton Elementary	NJ	Hedgepeth-Williams Elementary
CA	Lake View Elementary	IL	Glenbrook North High	NJ	Matawan Middle School
CA	Lakewood High School	IL	Greenville Elementary	NJ	Mountview Road School
CA	North Ridge Magnet	IL	Kilmer Elementary School	NJ	Notre Dame High School
CA	San Cayetano Elementary	IN	Franke Park Elementary	NJ	Peddie School
CA	Sequoia Middle School	IN	Lakeview Middle School	NJ	PJ Hill Elementary School
CA	The Jewish Community High School of the Bay	KS	Circle High School	NJ	Princeton High School
CA	Vintage Math, Science, and Technology Magnet	LA	Broadmoor Middle Laboratory School	NJ	Saint Peter's Preparatory
CA	Woodrow Wilson Middle	MA	Boston University Academy	NJ	South Brunswick High School
CO	Fox Meadow Middle School	MA	Robert L. Ford Elementary	NJ	St. Benedict's Preparatory
CO	Lakewood High School	MA	St. Marks School	NJ	Tom River's High School S
CO	Overland High School	MI	Middle School at Parkside	NJ	Trenton High School
CO	Warren Tech	MI	Milan High School	NJ	Union City High School
CT	East Hartford-Glastonbury Elementary Magnet School	MI	Warren Consolidated	NJ	Watchung Hills High School
DE	Delaware Agriscience	MN	Crossroads Elementary	NJ	Woodbury Jr. Sr. High School
DE	Dover High School	MN	Mayo High School	NM	Hoover Middle School
FL	Central Florida Aerospace Academy of Kathleen High	MO	Fulton High School	NM	Las Cruces High School
FL	Eagle's View Academy	MO	Jackson High School	NM	Mayfield High School
FL	Immokalee Middle School	MO	John Evans Middle School	NM	Vista Middle School
FL	Miami Christian School	MT	Anna Jeffries School	NV	The Academy of Math, Science, and Technology at Bridger Middle School
FL	Miami Dade County Public	MT	Glacier High School	NY	Canadaigua Academy
FL	Ocean Breeze Elementary	MT	Target Range School	NY	Fairport High School
FL	Oscar Patterson Elementary Magnet School	NC	Ferndale Middle School	NY	Lorraine Hansberry Academy
FL	Palm Beach County School District	NC	Greensboro Day School	NY	Milton Elementary School

OH	Beaumont High School	TX	Del Rio High School	TX	Orangefield High School
OH	Eastern Elementary School	TX	Dr. Rodriguez Elementary	TX	Ozen High School
OH	Luis Munoz Marin	TX	Edinburg North High School	TX	Penelope High School
OK	Elgin Public Schools	TX	Edna High School	TX	Pewitt High School
OR	Lake Oswego Junior High and High School	TX	G.W. Carver Academy	TX	Pharr-San Juan-Alamo High
OR	Portland Public Schools	TX	Gatesville High School	TX	Pittsburg High School
PA	Broughal Middle School	TX	Goliad High School	TX	Pleasant Grove High School
PA	Council Rock High School South	TX	Grand Prairie High School	TX	Rogers High School
PA	Jamestown High School	TX	Gregory-Portland Intermediate School	TX	Roosevelt High School
PA	West Philadelphia High	TX	H.M King High School	TX	Saltillo High School
PA	William Penn Senior High	TX	Hanby Elementary School	TX	Sam Rayburn Middle School
PR	Marcelino Canino Canino	TX	Harlingen High School	TX	San Benito High School
SC	Forest Lake Elementary Technology Magnet	TX	Hidalgo High School	TX	San Perlita High School
SD	Todd County Middle School	TX	Highland Park Middle School	TX	Santa Rosa High School
TN	Herman H. Battle Academy	TX	Hightower High School	TX	South Texas High School
TN	Hobgood Elementary	TX	Hirschi High School	TX	Spring Woods High School
TN	Lebanon Special School District	TX	Homer Hanna High School	TX	Sterling High School
TX	Aldine High School	TX	Industrial High School	TX	Stratford High School
TX	All Saints' Episcopal School	TX	Jarrell High School	TX	Sulphur Bluff High School
TX	Barbara Jordan High School	TX	Jefferson High School	TX	Sweetwater High School
TX	Belton High School	TX	Johnston Middle School	TX	Tahoka High School
TX	Blanco Middle School	TX	Laredo Martin High School	TX	Teague High School
TX	Booker T. Washington High School	TX	LBJ High School	TX	Thrall High School
TX	Bovina High School	TX	Liftoff Alumni	TX	United High School
TX	Bowie High School	TX	Longview High School	TX	Van Alstyne High School
TX	Brewer High School	TX	Los Fresnos High School	TX	West Oso High School
TX	Brownwood High School	TX	Lubbock High School	TX	West Ward Elementary School
TX	Camdem-Corrigan High	TX	Mabank High School	TX	Wharton High School
TX	Carlisle High School	TX	Magnolia High School	VA	K.W. Barrett Elementary
TX	Central High School	TX	Manvel High School	VA	Mack Benn Jr. Elementary School
TX	Chapel Hill High School	TX	Marble Falls ISD	VA	Oakcrest School for Girls
TX	Chester High School	TX	Merkel High School	VA	Oceanair Elementary School
TX	Chisum High School	TX	Miami High School	WA	Key Peninsula Middle School
TX	Clear Branch High School	TX	Midway ISD	WA	Roosevelt High School
TX	Clear Creek High School	TX	Nederland ISD	WI	Cumberland Middle School
TX	Clear Lake Intermediate	TX	New Caney High School	WI	Greendale High School
TX	Clear Springs High School	TX	New Deal High School	WI	Menomonie High School
TX	Como-Pickton High School	TX	New Summerfield High School	WI	Solon Springs Schools
TX	Crockett High School	TX	Nikki Rowe High School	WI	St. Mary's Visitation School
TX	Cypress Woods High School	TX	North Crowley High School	WV	Piedmont Elementary
TX	Daingerfield High School	TX	Northbrook High School	WY	East High School
TX	Dekalb High School	TX	Oak Hills Terrace Elementary		

2012 participants are highlighted in blue

Appendix 6 – 2004-2006 Museum and Informal Education Participating Institutions

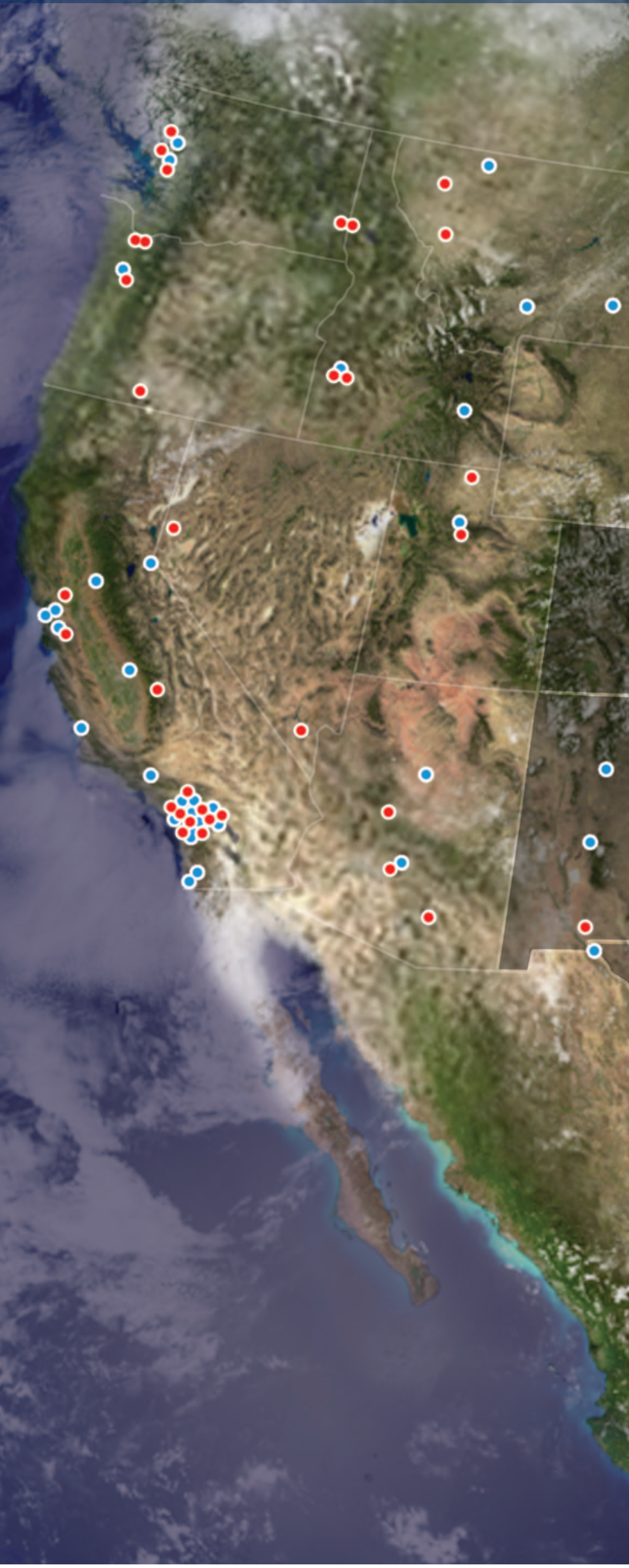
97 Flyers (does not include ground crew)
10 Institutions / 18 Teams / 9 States

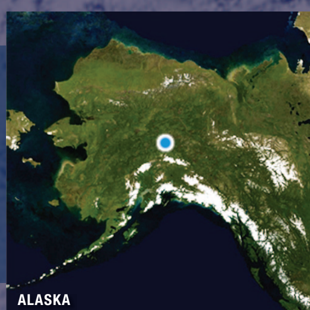
Institution Participation:

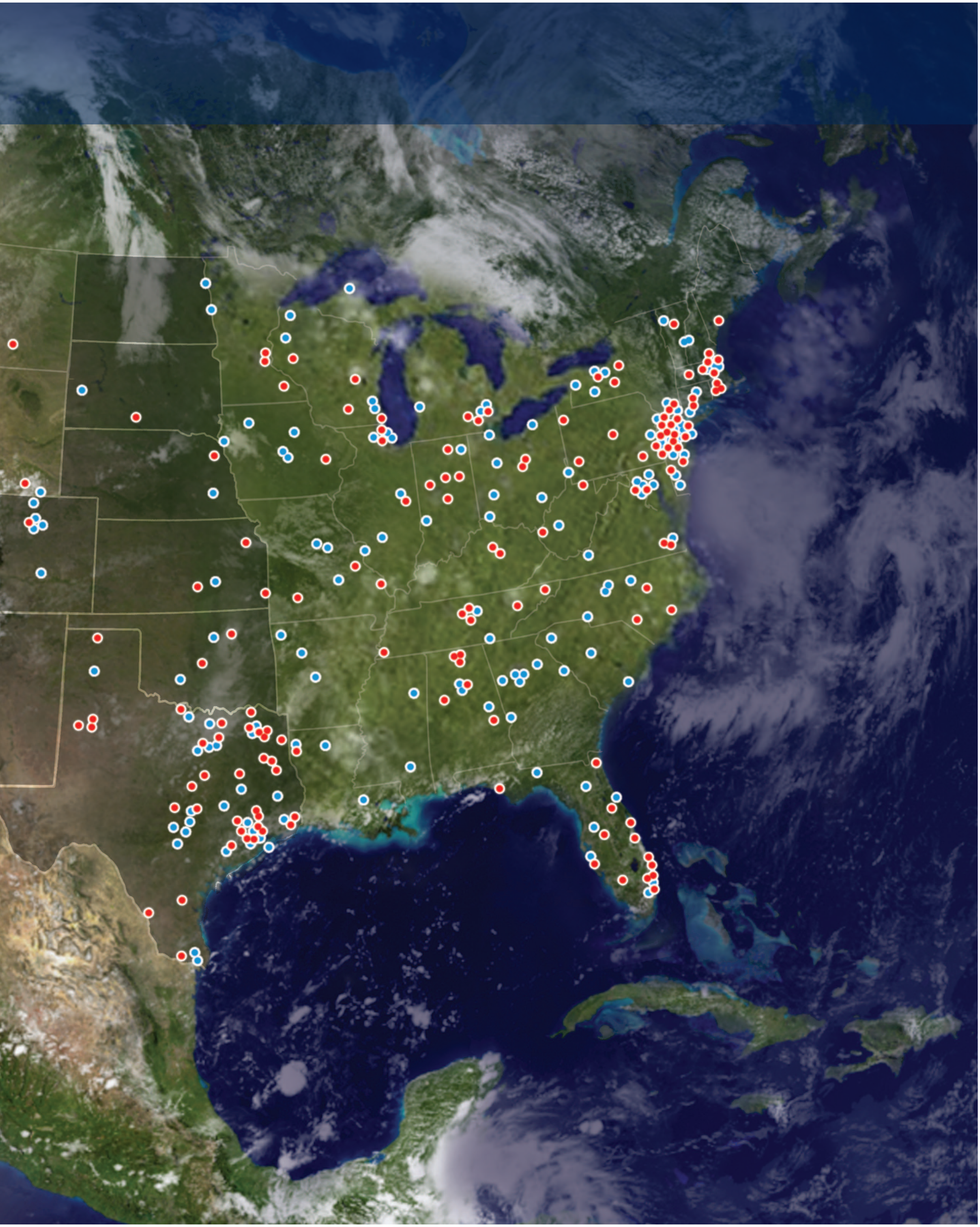
AL	McWane Center	MN	Headwaters Science Center	OH	Boonshoft Museum of Discovery
FL	Imaginarium	MO	St Louis Science Center	TN	Hands-On Regional Museum
GA	Coca-Cola Space Science Center	NJ	Liberty Science Center	TX	Space Center Houston
GA	Fernbank Science Center				

Appendix 7 – Summary Participation

Since its inception in 1995, the Reduced Gravity Program has hosted teams from all 50 states plus Washington, D.C., and Puerto Rico. The map represents the cities of all participating teams throughout the 17 years of the program. The blue points indicate higher education participants and the red points indicate high schools, teachers, and other organizations and groups.



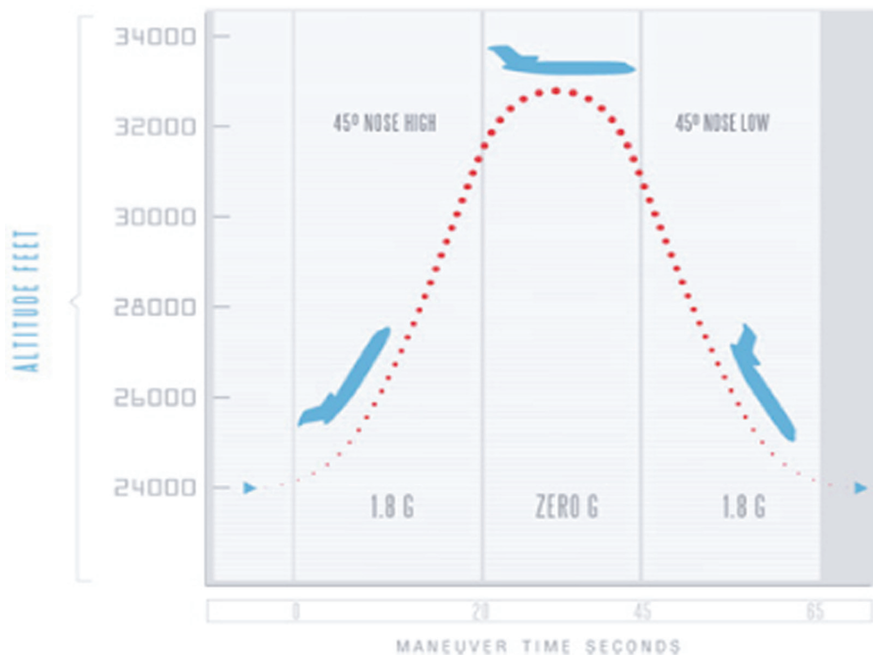




Appendix 8 – About the Microgravity Aircraft

The NASA-JSC Reduced Gravity Research Program flies on a modified Boeing 727 aircraft. The aircraft is crewed by a pilot, a copilot, a flight engineer, and two reduced gravity test directors. For the student campaign, a flight doctor, two video crew members and two photographers are also on board. Most test equipment is bolted to the floor using 20-inch tiedown grid attachment points.

The reduced gravity aircraft generally flies 30 parabolic maneuvers over the Gulf of Mexico. This parabolic pattern provides about 30 seconds of hypergravity (about 1.8G-2G) as the plane climbs to the top of the parabola. Once the plane starts to “nose over” the top of the parabola to descend toward Earth, the plane experiences about 18-25 seconds of microgravity (0G). At the very top and bottom of the parabola, flyers experience a mix of partial G’s between 0 and 1.8 (called “dirty air”).



Appendix 9 – Program History

Reduced Gravity Program Beginnings: In 1995, Ellington Field's Aircraft Operations Chief, Bob Naughton, accompanied NASA's reduced gravity aircraft to Europe to fly the European Space Agency's student parabolic flight campaign. Mr. Naughton, impressed with the success of ESA's flights, discussed the idea of a US parabolic flight campaign with NASA Headquarters and Johnson Space Center managers. Headquarters Education Chief Frank Owens liked the idea, as did (then) Deputy JSC Director George Abbey. In the summer of 1995, Abbey and Owens (with the support of the Texas Space Grant) prototyped the first US student parabolic flights.

1995 A pilot program was designed to provide a reduced gravity research opportunity for four teams of college seniors and graduate students from Texas' Rice and Texas A&M universities. The pilot program was called SURF (Students Understanding Reduced Gravity Flight).

1996 The program was repeated during the summer of 1996, again with four teams from Texas institutions. Lamar University, Rice University, Texas A&M University, and the University of Houston. In the Fall of 1996, SURF was renamed "Reduced Gravity Student Flight Opportunities Program (RGSFOP)" and expanded to include universities nationwide.

1997 Spring 1997 flights provided research opportunities for 23 teams from 15 states. For the first time, journalists were permitted to fly as "team members."

1998 The RGSFOP doubled program "slots" in 1998 to include 47 participating teams from 37 institutions in 24 states.

1999 A second yearly competition was born in 1999, which allowed for flights in both spring and summer. Forty-four teams from 33 institutions in twenty-one states participated during summer 1999.

2000 RGSFOP hosted 48 teams in March 2000. Because of KC-135 maintenance delays, 34 teams selected to participate in the Summer 2000 program were shifted into Spring 2001 program slots.

2001 Forty-eight teams participated in the Spring 2001 RGSFOP. Thirty-three teams were those shifted from the Summer 2000 program; the remaining 15 teams were selected during the Spring 2001 competition.

2002 The Aerospace Academy (a division of San Jacinto College) accepted administrative responsibilities for the Reduced Gravity Student Flight Opportunity Program. The Microgravity University Office was born. A program coordinator and deputy coordinator, under the direction of Dr. Donn Sickorez, assisted the 51 teams who participated in the Spring and Summer flight weeks for the 2002 campaign.

2003 A record number of 72 teams were chosen to participate. Among these were 17 first-time institutions and 11 minority teams. In addition, the program experienced an increase in minority participation.

2004 The RGSFOP extended offers to participate to 69 student teams. Three NASA Explorer Schools and one Informal Education team were also invited to participate as part of a pilot program. Although the student program has been in existence in some form for nearly a decade, it is continuing to reach new audiences. This year, six new institutions and seven minority institutions were among the selected teams. This was also the last student group to experience reduced gravity on the KC-135.

2005 The program moved to the C-9 aircraft. Modifications and issues with the aircraft caused delays and cancellations. In all, only 10 teams and 32 students flew. Teams were rolled over to the 2006 program.

2006 Flights returned to normal, as 65 teams are selected from 2005 and 2006 proposals. The first teams from Kansas, Pittsburg State and University of Kansas, fly their experiments. In addition, the first full group of museums and science centers are flown.

2007 In addition to the typical zero gravity parabolas, the student program's first lunar gravity experiments are flown. Lamar University, Michigan Technological University, and University of Missouri-Rolla flew experiments for 30 parabolas at 1/6G. Experiments ranged from lunar dust removal to welding.

2008 The program changed its name to the Reduced Gravity Education Flight Program (RGEFP) to reflect the teacher components. Two additional programs were added: Network of Educator Astronaut Teachers (NEAT) and the Systems Engineering Educational Discovery Program (SEED). Three states were also added to the participating states (Nebraska, Alaska, and Maine).

2009 The program moved to a contractor Boeing 727 aircraft. Through the special opportunities flight week, internal partnerships were explored as well as revisiting the policies of human-testing and the high school program.

2010 Four additional partnerships were added: The NASA Explorer Schools (NES) Opportunity flight week brought additional teams representing NASA Science, Engineering, Mathematics and Aerospace Academy (SEMAA) and Motivating Undergraduates in Science and Technology (MUST). An additional flight week was developed in conjunction with NASA Teaching from Space (TFS) Office and National Science Teachers Association (NSTA). Also added were two flight teams from the U.S. Department of Energy (DOE) in conjunction with the Princeton Plasma Physics Laboratory (PPPL).

2011 The total number of participants exceeded 500 individuals during the flight season, which is a record for the program. Also, three additional partnerships were added: The NASA Headquarters Office of Education provided funding for a flight week that focused on minority-serving institutions and community colleges. The National Space Grant Consortium funded a flight week for first-time participants. An official collaboration between the Reduced Gravity Education Flight Program and Princeton Plasma Physics Laboratory was established.

2012 The Reduced Gravity Education Flight Program officially has had at least one team from all 50 states (plus Washington DC and Puerto Rico). This milestone was achieved with the flight team from Delaware Technical and Community College. Twitter and a Facebook fan page (and social media plan) were implemented. NES Reduced Gravity program was redesigned to provide teams of educators with pre-designed experiments that were able to be tested by their students in the classroom (shared with NASA via videoconferences) and then tested in the aircraft.

Program Support

To successfully complete the flight season, it takes the effort and generous support of numerous groups and the Reduced Gravity Education Flight Program would like to take this opportunity to thank the following organizations and individuals.

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State Space Grant Consortium for supporting their flight teams

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Safety Reviewers from Johnson Space Center – Dominic Del Rosso, Christopher Nelson and Fernando Zumbado
Education Outreach Reviewers from Johnson Space Center

Program Support:

Ellington Field		**Mentors**	
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Test Director	Terry Lee	Ian Anchondo	Heather Paul
Office Manager	Rose Aquilina	Tess Caswell	Sarah Ruiz
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Engineer	Alyson Hickey	Tamra George	Robert Trevino
	Aircraft Operations	Johanna Goforth	Helen Vaccaro
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